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FOREWORD

1. STRUCTURE

This service manual has been prepared as an aid to improve the quality of repairs by giving the serviceman an accurate understanding of the product and by showing him the correct way to perform repairs and make judgements. Make sure you understand the contents of this manual and use it to full effect at every opportunity.

This service manual mainly contains the necessary technical information for operations performed in a service-workshop.

For ease of understanding, the manual is divided into the following sections.

SECTION 1 GENERAL

This section gives the general information of the machine and explains the safety hints for maintenance.

SECTION 2 REMOVAL & INSTALLATION OF UNIT

This section explains the procedures and techniques of removal and installation of each component.

SECTION 3 POWER TRAIN SYSTEM

This section explains the structure of the transmission as well as drive axle.

SECTION 4 BRAKE SYSTEM

This section explains the brake piping, each component and operation.

SECTION 5 STEERING SYSTEM

This section explains the structure of the steering unit.

SECTION 6 HYDRAULIC SYSTEM

This section explains the structure of the gear pump, main control valve as well as work equipment circuit, each component and operation.

SECTION 7 ELECTRICAL SYSTEM

This section explains the electrical circuit and each component.

It serves not only to give an understanding electrical system, but also serves as reference material for troubleshooting.

SECTION 8 MAST

This section explains the structure of mast, carriage, backrest and forks

The specifications contained in this service manual are subject to change at any time and without any advance notice. Contact your HD HYUNDAI distributor for the latest information.

2. HOW TO READ THE SERVICE MANUAL

Distribution and updating

Any additions, amendments or other changes will be sent to HD HYUNDAI distributors. Get the most up-to-date information before you start any work.

Symbols

So that the shop manual can be of ample practical use, important places for safety and quality are marked with the following symbols.

Symbols	Item	Remarks
	Safety	Special safety precautions are necessary when performing the work due to risk to human life
		Special safety precautions for work that might cause serious problem to equipment or surroundings.
	Caution	Useful information to operator or work that might cause issues to equipment and function.

Revised edition mark (①②③…)

When a manual is revised, an edition mark is recorded on the bottom outside corner of the pages.

Revisions

Revised information is shown at the list of revised pages on the between the contents page and next table.

Revision Table

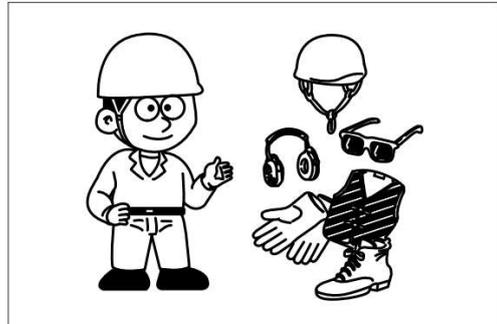
Revision	Version No.	Date	Note
00	9YMD-91020C	2023.08.30	The first printing
01	9YMD-91020C	2023.11.22	Cluster change
02	9YMD-91020C	2024.04.25	Add Differential (P33)

SECTION 1 GENERAL

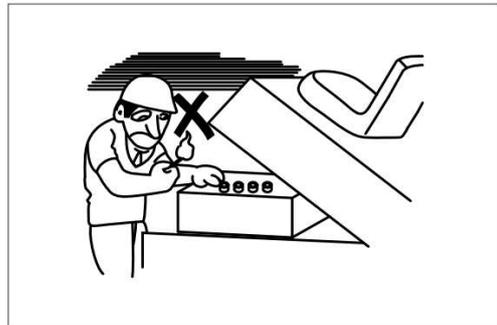
GROUP 1 SAFETY HINTS

Careless performing of the easy work may cause injuries. Take care to always perform work safely, at least observing the following.

- Oil is a dangerous substance. Never handle oil, grease or oily clothes in places where there is any fire or flame. As preparation in case of fire, always know the location and directions for use of fire extinguishers and other fire-fighting equipment.
- Wear well-fitting helmet, safety shoes and working clothes. When drilling, grinding or hammering, always wear protective goggles. Always wear safety clothes properly so that they do not catch on protruding parts of truck. Do not wear oily clothes. When checking, always release battery plug.



Flames should never be used instead of lamps. Never use a naked flame to check leaks or the level of oil or electrolyte.



When working on top of the machine, be careful not to lose your balance and fall.



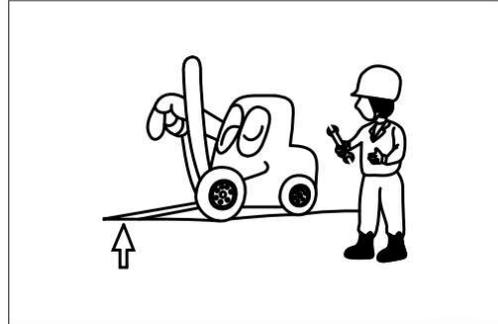
- Place a caution sign in the operator's compartment (For example: Do not start or Maintenance in progress).
This will prevent anyone from starting or moving the machine by mistake.



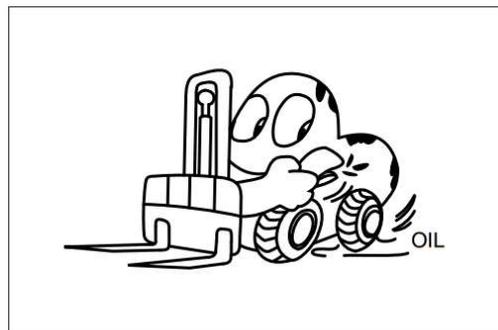
When inspecting running parts or near such parts, always stop the machine first.

Before checking or servicing accumulator or piping, depress brake pedal repeatedly to release pressure.

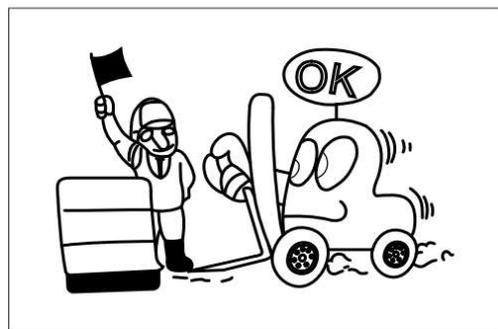
- Park the machine on firm, flat ground. Lower the fork to the ground and stop the engine. Return each lever to NEUTRAL and apply the brake lock.



- Immediately remove any oil or grease on the floor of the operator's compartment, or on the handrail. It is very dangerous if someone slips while on the machine.



- When working with others, choose a group leader and work according to his instructions. Do not perform any maintenance beyond the agreed work.



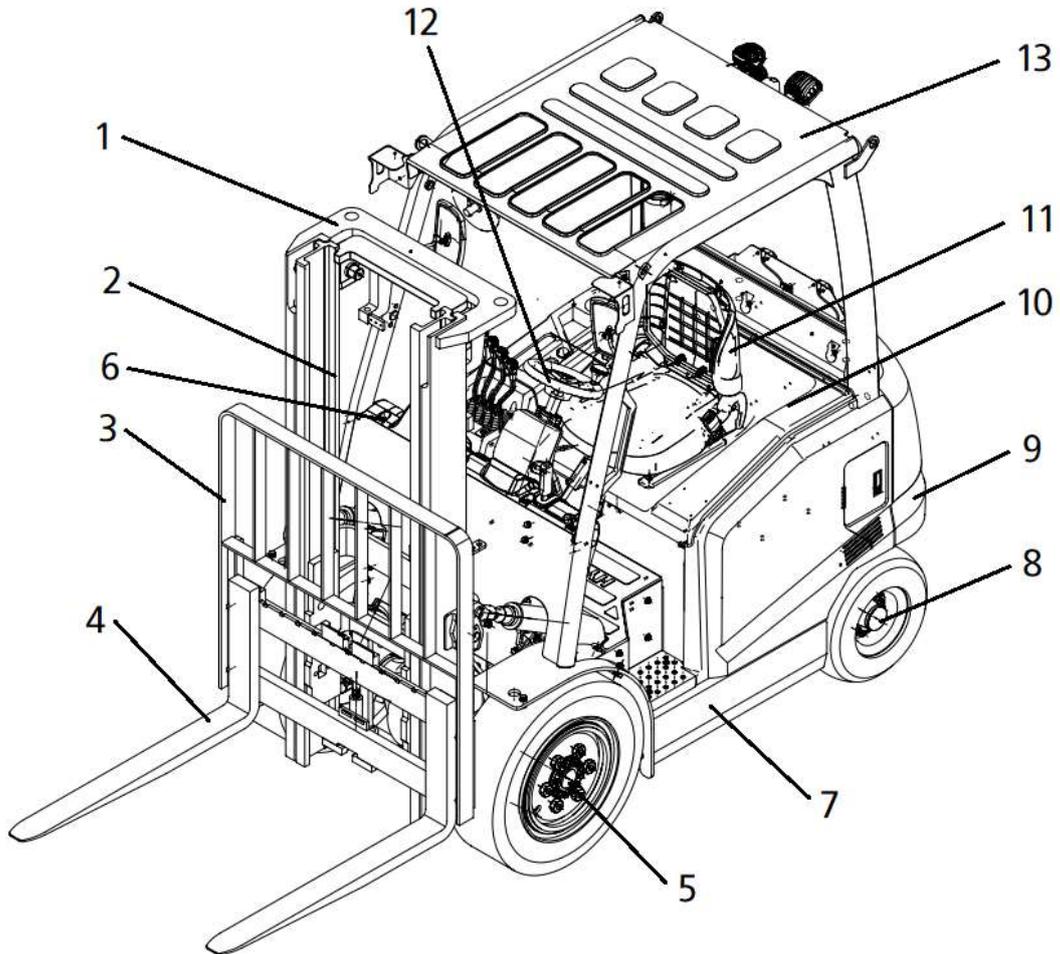
- Always remember that the hydraulic oil circuit is under pressure. When feeding or draining the oil or carrying out inspection and maintenance, release the pressure first.



- Unless you have special instructions to the contrary, maintenance should always be carried out with the machine stopped. If maintenance is carried out with the machine running, there must be two men present: one sitting in the operator's seat and the other one performing the maintenance. In such a case, never touch any moving part.
- Thoroughly clean the machine. In particular, be careful to clean the filler caps, grease fittings and the area around the dipsticks. Be careful not to let any dirt or dust into the system.
- Always use HD HYUNDAI Forklift genuine parts for replacement.
- Always use the grades of grease and oil recommended by HD HYUNDAI.
- Choose the viscosity specified for the ambient temperature.
- Always use pure oil or grease, and be sure to use clean containers.
- When checking or changing the oil, do it in a place free of dust, and prevent any dirt from getting into the oil.
- Before draining the oil, warm it up to a temperature of 30 to 40C.
- After replacing oil, filter element or strainer, bleed the air from circuit.
- When the strainer is located in the oil filler, the strainer must not be removed while adding oil
- When changing the oil filter, check the drained oil and filter for any signs of excessive metal particles or other foreign materials.
- When removing parts containing O-ring, gaskets or seals, clean the mounting surface and replace with new sealing parts.
- After injecting grease, always wipe off the oil grease that was forced out.
- Do not handle electrical equipment while wearing wet places, as this can cause electric shock.
- During maintenance do not allow any unauthorized person to stand near the machine.
- Be sure you fully understand the contents of the operation. It is important to prepare necessary tools and parts and to keep the operating area clean.
- When checking an open gear case there is a risk of dropping things in. Empty everything from your pockets before removing the covers to inspect such cases. Be particularly careful to remove wrenches and nuts
- Way to use dipstick
- Push the dipstick fully into the guide, and then pull out.
- Carrying out other difficult maintenance work carelessly can cause unexpected accidents. If you consider the maintenance is too difficult, always request the HD HYUNDAI Forklift distributor for help.

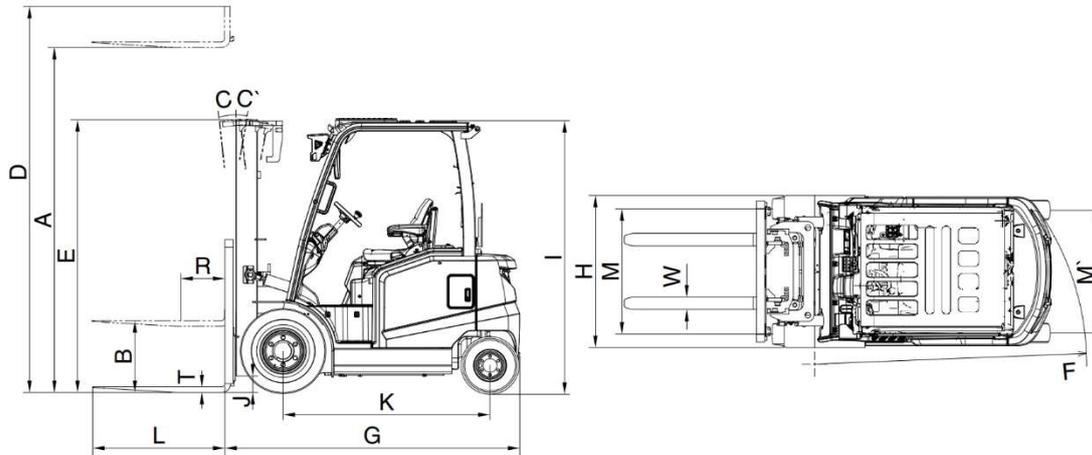
GROUP 2 SPECIFICATIONS

1. GENERAL LOCATIONS



- | | | |
|-------------------------|------------------|--------------------|
| 1 Mast | 6 Cluster | 11 Operator's seat |
| 2 Lift Cylinder | 7 Frame | 12 Steering wheel |
| 3 Carriage and backrest | 8 Steering | 13 Overhead guard |
| 4 Forks | 9 Counterweight | |
| 5 Drive axle | 10 Battery cover | |

2. SPECIFICATIONS



Item		Unit	16BE-X	20BE-X
Rated load		kg	1600	2000
Center of gravity	R	mm	500	←
Weight		kg	3323	3678
Forks	Lifting height	A	mm	←
	Free lift	B	mm	←
	Lifting speed (load/non-load)		mm/sec	←
	Lowering speed (load/non-load)		mm/sec	←
	Length × width × thickness		mm	←
Mast	Tilt angle(F/R)	C/C'	Degree	←
	Max. height	D	mm	←
	Min. height	E	mm	←
Others	Travel speed (load/non-load)		km/h	←
	Max. gradeability (load)		%	←
	Min. turning radius (outside)	F	mm	←
	Max. hydraulic force		MPa	←
	Hydraulic oil tank		l	←
Overall length	G	mm	←	
Overall width	H	mm	←	
Overhead guard height	I	mm	←	
Ground clearance (mast)	J	mm	←	
Distance between axles	K	mm	←	
Distance between wheels	M/M'	mm	←	

3. SPECIFICATION FOR MAJOR COMPONENTS

1) CONTROLLER

Item	Unit	16/20BE-X	
Controller	-	Drive	Pump
Model	-	ZAPI ACE2 NEWGEN	←
Type	-	AC	←
Current limit	V-A	48-400	←
Communication	-	CAN	←

2) MOTOR

Item	Unit	16/20BE-X	
Motor	-	Drive	Pump
Type	-	YST8H4-9-001	YSP5H4-13-001
Rated voltage	Vac	29.5	29.5
Output	kW	9	13
Insulator	-	H	H

3) BATTERY

Item	Unit	16BE-X	20BE-X
Type	-	Plumbic acid	←
Rated voltage	V	48	←
Capacity	AH/hr	420/5	←
Electrolyte	-	Wet	←
Dimensions (W×L×H)	mm	826×422×744	←
Connector	-	SB350	←
Weight	kg	727	←

LITHIUM ION BATTERY (OPT)

Item	Unit	16BE-X	20BE-X
Rated voltage	V	51.2	←
Capacity	AH	300	←
Dimensions (W×L×H)	mm	826×422×744	←
Weight	kg	727	←
Connector	-	DIN 320	←

4) CHARGER

Item	Unit	16BE-X	20BE-X
Capacity of battery for charging	V-AH	48V/420-450	←
AC input	V	3-Phase,220	←
		3-Phase,380	←
		3-Phase,440	←
DC output	V	68±0.5	←
Charging time	hr	8±1	←
Connector	-	SB 350	←

LITHIUM ION CHARGER (OPT)

Item	Unit	16BE-X	20BE-X
Capacity of battery for charging	V-AH	51.2-300	←
AC input	V	3-Phase, 380-440	←
DC output	V	57.5-58	←
Charging time	hr	2.5	←
Connector	-	DIN 320	←

5) GEAR PUMP

Item	Unit	16BE-X	20BE-X
Type	-	Out gear pump	←
Capacity	cc/rev	21	←
Max. working pressure	bar	206	←
Rated rotation rate (max/min)	rpm	3000/500	←

6) MAIN CONTROL VALVE

Item	Unit	16/20BE-X
Type	-	2/3/4 spools
Operating mode	-	Mechanical
Primary relief valve pressure	bar	195
Secondary relief valve pressure	bar	160

7) T/M

Item	Unit	16/20BE-X
Type	-	Integrated
Stage	-	1/1
Transmission ratio	-	25.047
Noise (Rated input speed)	dB(a)	86
Transmission efficiency	-	≥90%

8) WHEEL

Item	16BE-X	20BE-X
Type (front/rear)	Solid (opt: pneumatic, no-marking)	←
Quantity (front/rear)	2/2	←
Front-wheel drive	21*8-9-16PR	28*9-15-16PR
Rear-wheel drive	18*7-8-14PR	←

9) BRAKE AND STEERING SYSTEMS

Item		16/20BE-X
Brake	Traveling	Front-wheel mounted, dry disk mode
	Parking	Mechanical
Steering	Type	Hydraulic steering

4. TIGHTENING TORQUE FOR MAJOR COMPONENTS

Sequences		Item	Screw specifications	kgf-m
1	Electric systems	hydraulic pump motor mounting nut	M10 × 1.5	5.0 ± 0.7
2		Drive motor mounting bolt	M14 × 1.5	15.7 ± 3.0
3	Hydraulic systems	hydraulic pump mounting bolt	M10 × 1.5	6.9 ± 0.5
4		MCV mounting bolt, nut	M10 × 1.5	6.9 ± 0.5
5		Steering unit mounting bolt	M10 × 1.5	5.0 ± 0.5
6		Tilt cylinder rod-end bolt, nut	M12 × 1.75	9.5 ± 0.5
7		Tilt cylinder pin mounting bolt	M10 × 1.5	6.9 ± 0.5
8	Powertrain system	Drive axle mounting bolt, nut	M16 × 2.0	29.5 ± 0.5
9		Steering axle mounting bolt, nut	M20 × 2.5	57.5 ± 8.0
10		Transmission mounting bolt, nut	M10 × 1.25	7.5 ± 0.5
11		Front wheel mounting nut	M16 × 1.5	30 ± 3.0
12		Rear wheel mounting nut	M14 × 1.5	21 ± 1.5
13	Others	Counterweight mounting bolt	M24 × 3.0	73.5 ± 15
14		Mast mounting bolt	M16 × 2.0	36.5 ± 7.0
15		Operator's seat mounting nut	M8 × 1.25	3.4 ± 0.7
16		Overhead guard mounting bolt (front)	M12 × 1.75	12.0 ± 0.5
17		Overhead guard mounting bolt (rear)	M12 × 1.75	12.0 ± 0.5

5. TORQUE CHART

Use following table for unspecified torque

1) BOLT AND NUT

① Coarse thread

Bolt size	8.8T	10.9T	12.9T
	kgf·m	kgf·m	kgf·m
M 6 × 1.0	0.8 ~ 1.2	1.2 ~ 1.8	1.5 ~ 2.1
M 8 × 1.25	2.0 ~ 3.0	2.8 ~ 4.2	3.4 ~ 5.0
M10 × 1.5	4.0 ~ 6.0	5.6 ~ 8.4	6.8 ~ 10.0
M12 × 1.75	6.8 ~ 10.2	9.6 ~ 14.4	12.3 ~ 16.5
M14 × 2.0	10.9 ~ 16.3	16.3 ~ 21.9	19.5 ~ 26.3
M16 × 2.0	17.9 ~ 24.1	25.1 ~ 33.9	30.2 ~ 40.8
M18 × 2.5	24.8 ~ 33.4	34.8 ~ 47.0	41.8 ~ 56.4
M20 × 2.5	34.9 ~ 47.1	49.1 ~ 66.3	58.9 ~ 79.5
M22 × 2.5	46.8 ~ 63.2	65.8 ~ 88.8	78.9 ~ 106
M24 × 3.0	60.2 ~ 81.4	84.6 ~ 114	102 ~ 137
M30 × 3.5	120 ~ 161	168 ~ 227	202 ~ 272

② Fine thread

Bolt size	8.8T	10.9T	12.9T
	kgf·m	kgf·m	kgf·m
M 8 × 1.0	2.1 ~ 3.1	3.0 ~ 4.4	3.6 ~ 5.4
M10 × 1.25	4.2 ~ 6.2	5.9 ~ 8.7	7.0 ~ 10.4
M12 × 1.25	7.3 ~ 10.9	10.3 ~ 15.3	13.1 ~ 17.7
M14 × 1.5	12.4 ~ 16.6	17.4 ~ 23.4	20.8 ~ 28.0
M16 × 1.5	18.7 ~ 25.3	26.3 ~ 35.5	31.6 ~ 42.6
M18 × 1.5	27.1 ~ 36.5	38.0 ~ 51.4	45.7 ~ 61.7
M20 × 1.5	37.7 ~ 50.9	53.1 ~ 71.7	63.6 ~ 86.0
M22 × 1.5	51.2 ~ 69.2	72.0 ~ 97.2	86.4 ~ 116
M24 × 2.0	64.1 ~ 86.5	90.1 ~ 121	108 ~ 146
M30 × 2.0	129 ~ 174	181 ~ 245	217 ~ 294

2) PIPE AND HOSE (FLARE TYPE)

Thread (PF)	Hex. across flat (mm)	kgf·m
1/4"	19	4
3/8"	22	5
1/2"	27	9.5
3/4"	36	18
1"	41	21
1-1/4"	50	35

3) PIPE AND HOSE (ORFS TYPE)

Thread (UNF)	Hex. across flat (mm)	kgf·m
9/16-18	19	3
11/16-16	22	5
13/16-16	24	7
1-14	30	12
1-3/16-12	36	18
1-7/16-12	41	23
1-11/16-12	50	28
2-12	58	32

4) FITTING

Thread	Hex. across flat (mm)	kgf·m
1/4"	17	2
3/8"	19	3
1/2"	22	4
	24	6
5/8"	27	10
	30	12
3/4"	32	15
	36	18
1"	41	23
1-1/4"	50	28
1-1/2"	55	32

5) BAND CLAMP

Tag. No.	Hose size (mm)	Band width (mm)	kgf·m
S20-15	8 ~ 14	9	0.3
S20-17	11 ~ 17		
S20-22	13 ~ 20		
S20-25	15 ~ 24		
S20-28	19 ~ 28		
S20-32	22 ~ 32	12	0.35
S20-40	26 ~ 38	9	
S20-45	32 ~ 44		

6) BAND CLAMP (IDEAL, FLEX-GEAR TYPE)

Tag. No.	Hose size (mm)	Band width (mm)	kgf·m
41-212	32 ~ 54	15.9	1.1
41-262	45 ~ 67		
41-312	57 ~ 79		
41-362	40 ~ 92		
41-412	83 ~ 105		
41-462	95 ~ 117		
41-512	108 ~ 130		

6. WRENCH AND SPANEER CHART

No.	Wrench & Spanner		Specification			Pipe and Hose		
	inch	mm	UNF/UN	M	PF/G	ORFS (UNF/UN)	FLARE (PF)	
1	-	0.050	1.3	-	-	-	-	-
2	-	0.059	1.5	-	-	-	-	-
3	1/16	0.063	1.6	-	-	-	-	-
4	5/64	0.078	2	-	-	-	-	-
5	3/32	0.094	2.4	-	-	-	-	-
6	-	0.098	2.5	-	-	-	-	-
7	7/64	0.109	2.8	-	-	-	-	-
8	-	0.118	3	-	-	-	-	-
9	1/8	0.125	3.2	-	-	-	-	-
10	9/64	0.141	3.5	-	-	-	-	-
11	5/32	0.156	4	-	-	-	-	-
12	-	0.177	4.5	-	-	-	-	-
13	3/16	0.188	4.8	-	-	-	-	-
14	-	0.197	5	-	-	-	-	-
15	13/64	0.203	5.2	-	-	-	-	-
16	7/32	0.219	5.5	-	-	-	-	-
17	15/64	0.234	6	-	-	-	-	-
18	1/4	0.250	6.4	-	-	-	-	-
19	17/64	0.266	6.8	-	-	-	-	-
20	9/32	0.281	7	-	-	-	-	-
21	5/16	0.313	8	-	-	-	-	-
22	11/32	0.344	8.7	-	-	-	-	-
23	-	0.354	9	-	-	-	-	-
24	3/8	0.375	9.5	-	-	-	-	-
25	-	0.394	10	-	-	-	-	-
26	-	-	11	-	-	-	-	-
27	7/16	0.438	11.1	-	-	-	-	-
28	15/32	0.469	12	-	-	-	-	-
29	1/2	0.500	12.7	-	-	-	-	-
30	-	-	13	-	-	-	-	-
31	17/32	0.53	13.5	-	-	-	-	-
32	-	0.55	14	7/16-20	-	-	-	-
33	9/16	0.56	14.3	-	-	-	-	-
34	19/32	0.59	15	-	-	-	-	-
35	5/8	0.63	15.9	-	-	-	-	-
36	-	-	16	-	-	-	-	-
37	21/32	0.66	16.7	-	-	-	-	-
38	-	-	17	-	M12	-	-	-

No.	Wrench & Spanner		Specification			Pipe and Hose		
	inch	mm	UNF/UN	M	PF/G	ORFS (UNF/UN)	FLARE (PF)	
39	11/16	0.69	17.5	-	-	-	-	-
40	-	-	18	-	-	-	-	-
41	3/4	0.75	19	9/16-18	M14	G1/4	9/16-18	PF1/4
42	25/32	0.78	19.8	-	-	-	-	-
43	-	-	20	-	-	-	-	-
44	13/16	0.81	20.6	-	-	-	-	-
45	-	-	21	-	-	-	-	-
46	-	-	22	-	M16	G3/8	11/16-16	PF3/8
47	7/8	0.88	22.2	-	-	-	-	-
48	29/32	0.91	23	-	-	-	-	-
49	15/16	0.94	23.8	-	-	-	-	-
50	-	-	24	3/4-16	M18	-	13/16-16	-
51	31/32	0.97	26.4	-	-	-	-	-
52	-	-	25	-	-	-	-	-
53	1	1.00	25.4	-	-	-	-	-
54	-	-	26	-	-	-	-	-
55	1 1/16	1.06	27	7/8-14	M22	G1/2	-	PF1/2
56	-	-	28	-	-	-	-	-
57	1 1/8	1.13	28.6	-	-	-	-	-
58	-	-	29	-	-	-	-	-
59	-	-	30	-	-	-	1-14	-
60	1 3/16	1.19	30.2	-	-	-	-	-
61	-	-	31	-	-	-	-	-
62	1 1/4	1.25	31.8	-	-	-	-	-
63	-	-	32	1-1/16-12	M24	G3/4	-	-
64	-	-	33	-	-	-	-	-
65	1 5/16	1.31	33.3	-	-	-	-	-
66	-	-	34	-	-	-	-	-
67	1 3/8	1.38	35	-	-	-	-	-
68	-	-	36	1-3/16-12	M27	G3/4	1-3/16-12	PF3/4
69	1 7/16	1.44	37	-	-	-	-	-
70	1 1/2	1.50	38	-	-	-	-	-
71	-	-	39	-	-	-	-	-
72	1 9/16	1.56	39.7	-	-	-	-	-
73	-	-	40	-	-	-	-	-
74	-	-	41	1-5/16-12	M33	G1	1-7/16-12	PF1
75	1 5/8	1.63	41.3	-	-	-	-	-
76	1 11/16	1.69	43	-	-	-	-	-

No.	Wrench & Spanner		Specification			Pipe and Hose		
	inch	mm	UNF/UN	M	PF/G	ORFS (UNF/UN)	FLARE (PF)	
77	1 3/4	1.75	44	-	-	-	-	-
78	1 13/16	1.81	46	-	-	-	-	-
79	1 7/8	1.88	47.6	-	-	-	-	-
80	-	-	48	-	-	-	1-11/16-12	-
81	1 15/16	1.94	49.2	-	-	-	-	-
82	-	-	50	1-5/8-12	-	G1-1/4	-	PF1-1/4
83	2	2.00	50.8	-	-	-	-	-
84	-	-	51	-	-	-	-	-
85	2 1/8	2.13	54	-	-	-	-	-
86	-	-	55	1-7-8-12	-	G1-1/2	-	PF1-1/2
87	-	-	57	-	-	-	2-12	-
88	2 1/4	2.25	57.2	-	-	-	-	-
89	-	-	60	-	-	-	-	-

7. RECOMMENDED LUBRICANTS

Use only oils listed below or equivalent. Do not mix different brand oil.

Item	Lubricant type	Capacity (L)	Ambient temperature °C (°F)								
			-50	-30	-20	-10	0	10	20	30	40
			(-58)	(-22)	(-4)	(14)	(32)	(50)	(68)	(86)	(104)
Axle	Gear oil	3.5	★85W90 GL5								
Hydraulic oil tank	Hydraulic oil	33	★ISO VG 15								
			ISO VG 32								
			ISO VG 46								
			ISO VG 68								
Brake system	Brake oil	0.25	★DOT3								
Fitting (Grease nipple)	Grease	0.1	★NLGI No.1								
			NLGI No.2								

★: Regions of cold climate (Russia, CIS, Mongolia)

GROUP 3 PERIODIC REPLACEMENT

For operation safety, never fail to perform periodic maintenance or make periodic replacement of the consumable parts listed in the following. These parts may deteriorate in time and are susceptible to wear.

It is difficult to estimate the degree of wear at time of periodic maintenance; therefore, even if no apparent wear is found, always replace with new parts within the prescribed period of replacement (Or earlier if trouble is found).

Note that periodic replacement has nothing to do with guarantee service.

※ Replacement of consumable service parts is not covered under warranty.

No.	Name	Replacement cycle
1	Master cylinder and wheel cylinder caps dust seals	Every 1 year
2	Lift cylinder hose	Every 1 year (harsh operation) Every 2 years (normal operation)
3	Tilt cylinder hose	
4	Side shift cylinder hose	
5	Brake hose or tube	Every 2 years
6	Hydraulic pump hose	
7	Power steering hose	
8	Coolant hose and clamps	
9	Packing, seal, and O-ring of steering cylinder	Every 2 years (harsh operation) Every 4 years (normal operation)
10	Lift chain	
11	Brake oil tank tube	Every 3 years
12	Hydraulic pump seal kit	
13	Pressure sensor	Every 5 years

※ Replace the O-ring and gasket at the same time when replacing the hose.

※ Replace clamp at the same time if the hose clamp is cracked when checking and replacing hose.

※ Normal operation

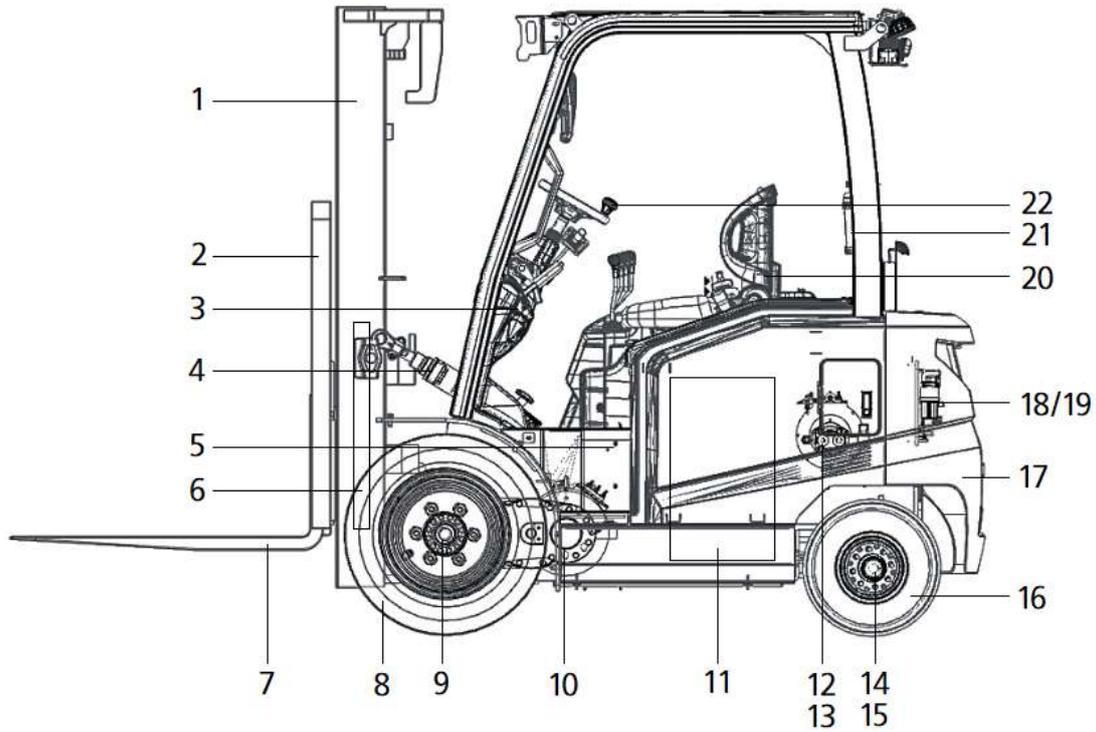
Eight hours material handling, mostly in buildings or in clean, open air on clean paved surfaces.

※ Harsh operation

- 1) All harsh working environment
- 2) Long term heavy load operation
- 3) High and low temperature working environment
- 4) Sudden change in temperature
- 5) Dusty or sandy working environment
- 6) Highly corrosive chemical working environment
- 7) Damp working environment

SECTION 2 REMOVAL & INSTALLATION OF UNIT

GROUP 1 MAJOR COMPONENTS



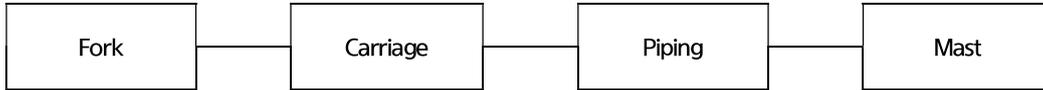
- | | | |
|----------------------|------------------------|---------------------|
| 1 Mast | 9 Drive axle | 17 Counterweight |
| 2 Backrest | 10 Drive motor | 18 Traction control |
| 3 Steering unit | 11 Battery | 19 Pump control |
| 4 Tilt cylinder | 12 Pump motor | 20 Seat |
| 5 Main control valve | 13 Hydraulic gear pump | 21 Overhead guard |
| 6 Lift cylinder | 14 Steering cylinder | 22 Steering wheel |
| 7 Fork | 15 Steering axle | |
| 8 Front wheel | 16 Rear wheel | |

GROUP 2 REMOVAL AND INSTALLATION OF UNIT

Remove and install following units as explained in the flow chart.

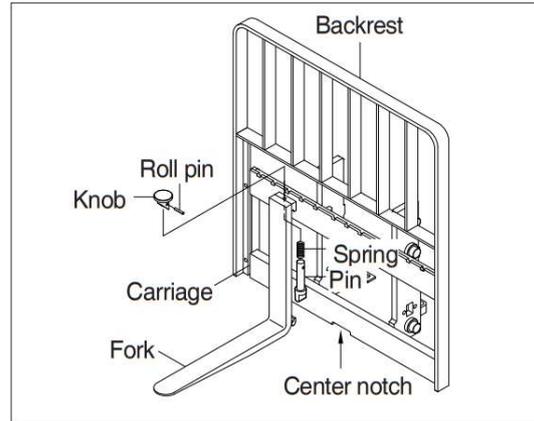
1. MAST

REMOVAL



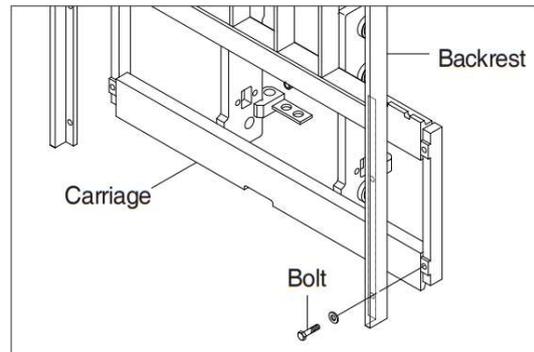
1) Forks

- ① Lower the fork carriage until the forks are approximately 25 mm from the floor.
 - ② Turn knob up and slide one fork at a time toward the center of the carriage where a notch has been cut in the bottom plate for easy removal.
 - ③ Remove only one fork at a time.
- ※ On larger forks it may be necessary to use a block of wood.



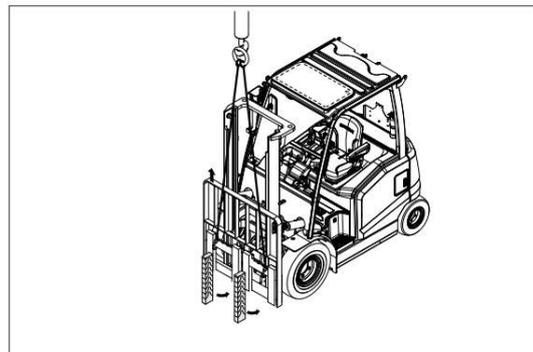
2) Backrest (If necessary)

Remove bolts securing backrest to fork carriage. Lift backrest straight up and remove it from carriage.

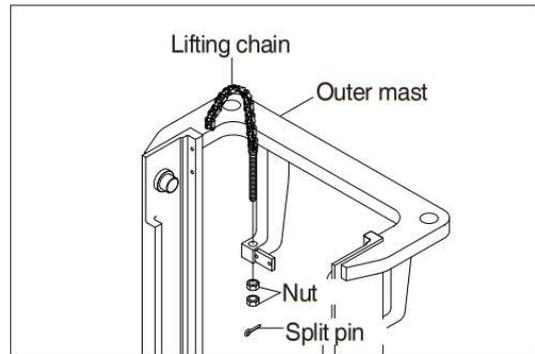


3) Carriage

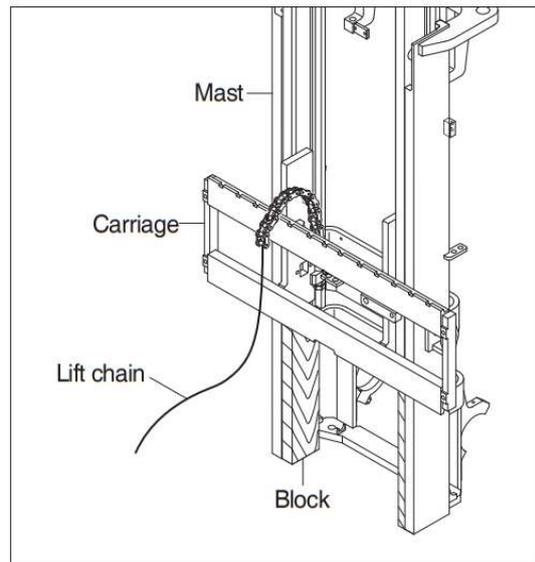
- ① With the mast vertical, raise the carriage high enough to place blocks under the carriage. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is raised.



- ② While supporting lift chains, remove the split pin and nuts from the chain anchor.

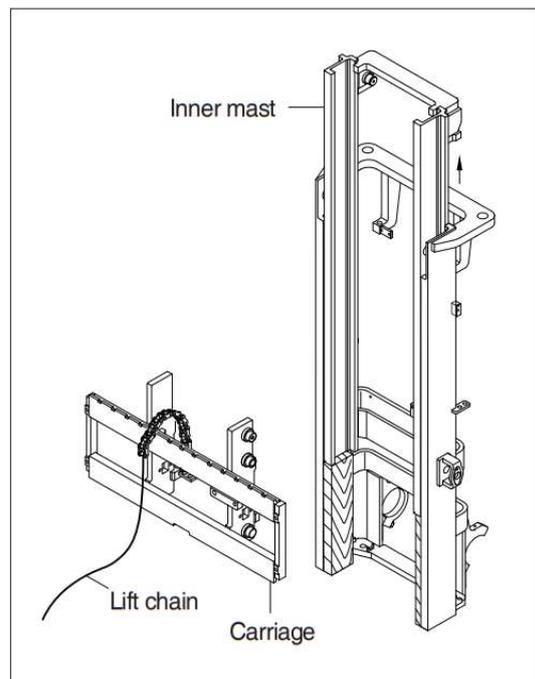


- ③ Pull the chains out of the sheaves and drape them over the front of the carriage.



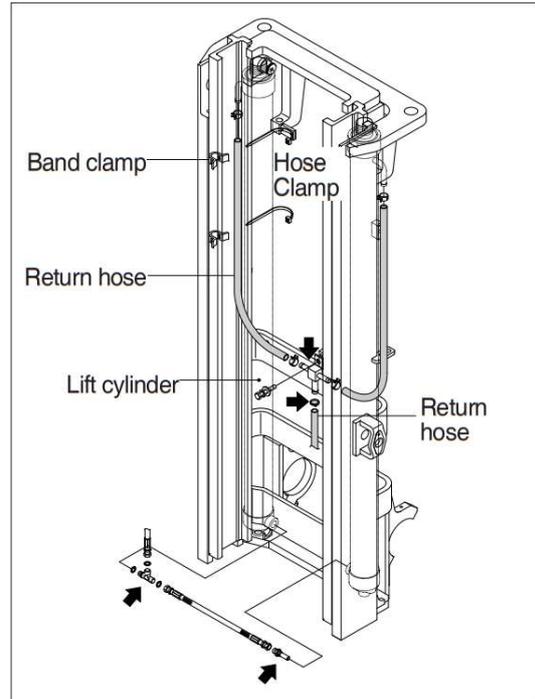
- ④ Slowly raise inner mast upright until mast clears top of fork carriage. Move carriage to work area and lower the mast.

- ▲ Make sure that carriage remains on floor and does not bind while mast is being raised.
- ※ Inspect all parts for wear or damage. Replace all worn or damaged parts.



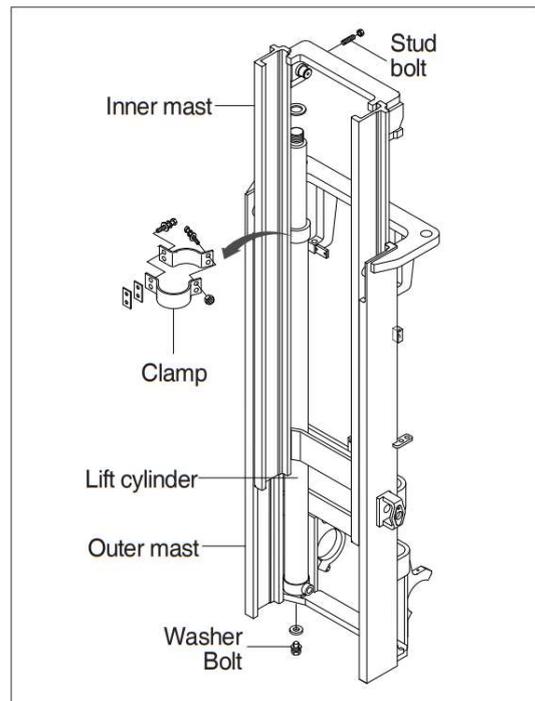
4) Piping

- ① Remove the return hoses and clamps attached to the lift cylinder
- ② Remove hose assembly, valve and connector from the lift cylinder
- ※ Put blind plugs in the piping immediately after removing hoses to prevent the hydraulic oil from flowing out and also prevents dust and dirt from getting in.



5) Lift cylinder

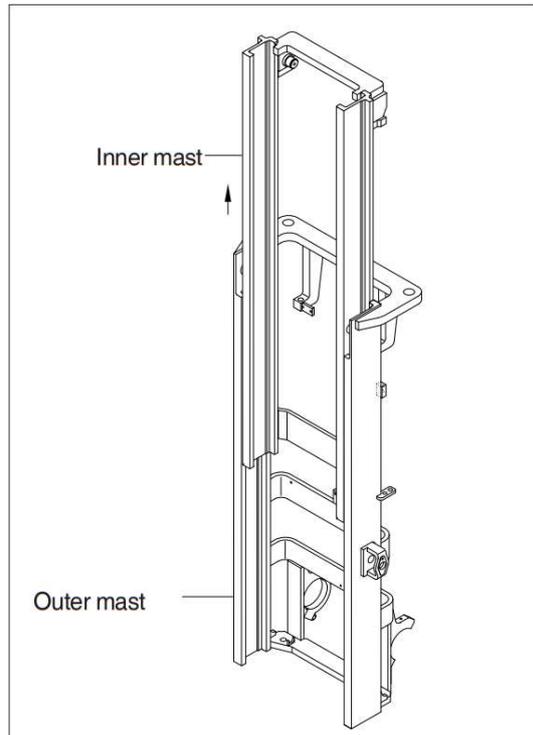
- ① Loosen and remove stud bolts and washers and secure lift cylinders to outer mast.
- ② Bind the lift cylinder with overhead hoist rope and pull up so that the rope has no slack or binding.
- ※ Make sure that the lift cylinder be tightened firmly for safety.
- ③ Loosen and remove hexagon bolts and nuts securing the cylinder.
- ④ Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
- ⑤ Using an overhead hoist, draw out lift cylinder carefully and put down on the work floor.



6) Inner mast

Using an overhead hoist raise the inner mast straight and carefully draw out of outer mast section.

▲ Be careful the mast not to swing or fall.



7) Tilt cylinder pin

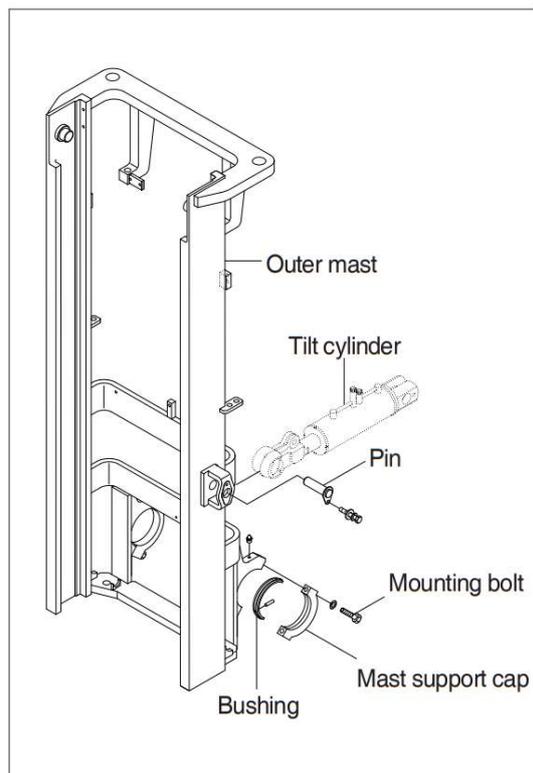
Loosen the bolt and remove the tilt cylinder pin.

8) Mast mounting pin

① Attach a crane to the stay at the top of the outer mast, and raise enough to sustain jacked up truck.

※ This operation is carried out under the truck, so use a pit, or if there is no pit, jack up the truck and loosen with an impact wrench.

② Loosen the mounting socket bolts and remove the mast mounting pins. Then slowly raise the outer mast.



INSTALLATION

After assembling mast components totally without piping connections, install mast assembly to the equipment.

※ Installation procedure for each of mast component is the reverse of the removal procedure.

1) Mast support cap

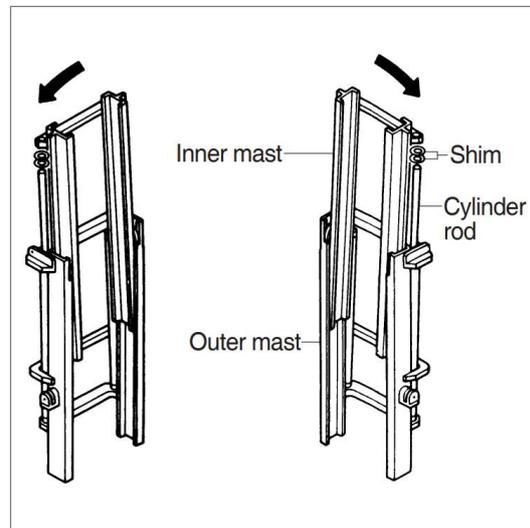
- ① Check mast mounting bolts and bushings for wear.
- ② Jack up the truck so that the front is raised and then using an overhead hoist assemble outer mast to drive axle unit.
- ③ Tighten mast support cap and mounting bolts to mast. Lubricate with GTP 600 or 1000 PASTE. Tightening torque: 24.5 ± 2.5 kgf·m,

2) Tilt cylinder pin

Hold the mast with a crane, operate the tilt control lever and align the holes, then knock the pin

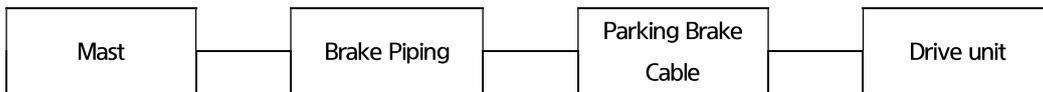
3) Lift cylinder installation and adjustment

- ① Assemble the lift cylinder inside the outer mast, then tighten the stopper bolt. If the cylinder assembly has been replaced, adjust as follows so that the left and right cylinders are synchronized at the maximum lifting height.
- ② Assemble the cylinder rod to the inner mast, and check the left-to-right play of the mast at the maximum lifting height.
 - ※ If play is to LEFT, install adjustment shim to LEFT cylinder.
 - ※ If play is to RIGHT, install adjustment shim to RIGHT cylinder.
 - ※ Shim thickness: 1.0 mm.



2. POWER TRAIN ASSEMBLY

REMOVAL



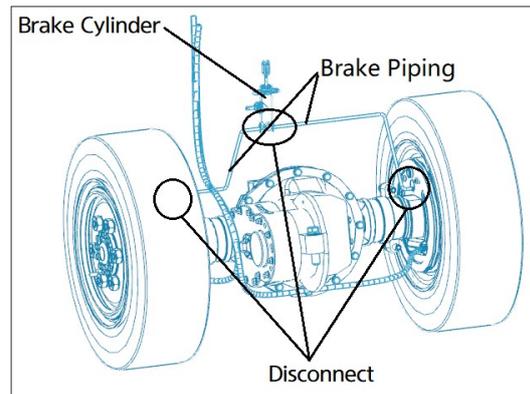
1) Mast

Refer to section on mast to remove mast.

2) Brake Piping

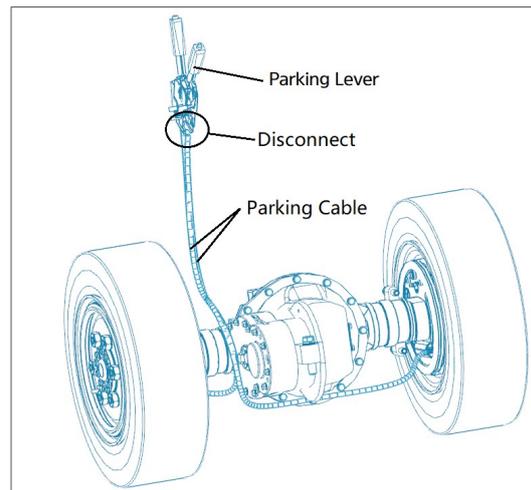
Disconnect the service brake piping from the brake housing of drive axle.

※ Brake oil will flow out after the pipe is removed.



3) Parking brake cable

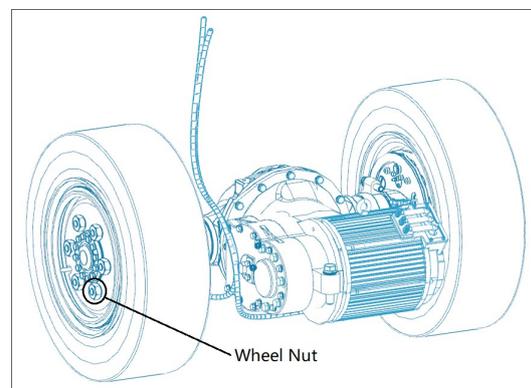
Remove the Parking cable from the drive axle.



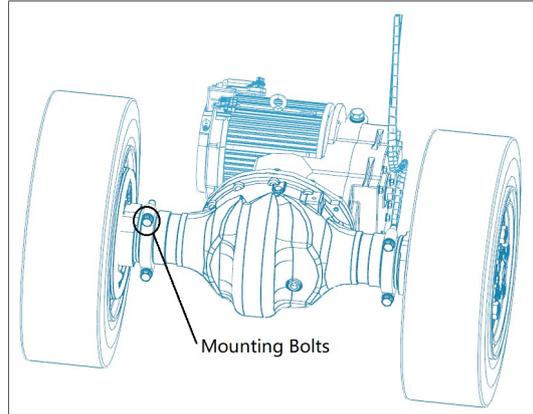
4) Drive axle and drive motor

※ Before removing the drive axle unit, remove all of the oil from the axle.

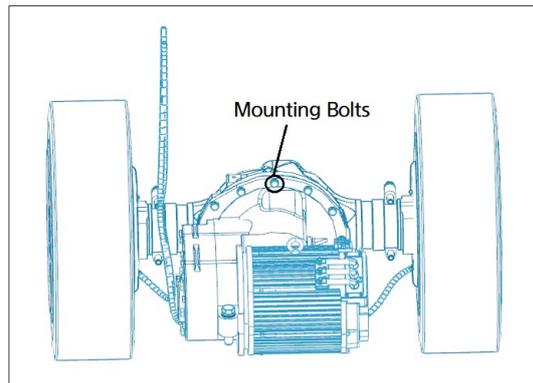
① Unscrew 12 wheel-nuts and remove the wheels.



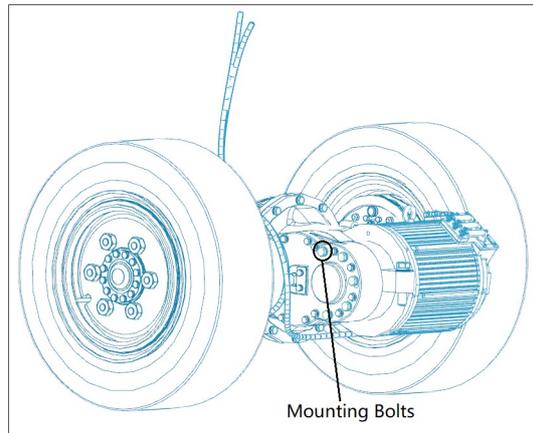
- ② Remove 4 mounting bolts fixing the axle to the frame and carefully remove the drive motor and axle from the vehicle.



- ③ Remove 5 mounting bolts fixing the transmission and motor to the axle and carefully remove the transmission and drive motor from the drive axle.

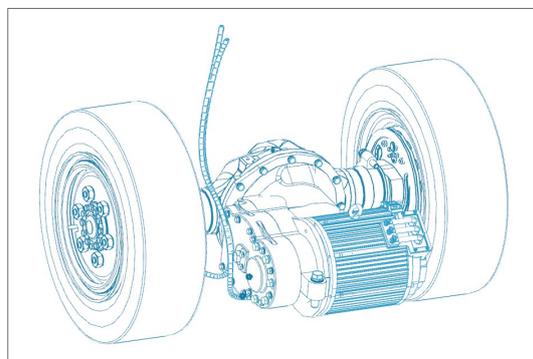


- ④ Remove 12 mounting bolts fixing the motor to the transmission and carefully remove the drive motor from the transmission.



INSTALLATION

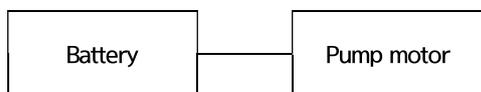
Installation is the reverse order of removal.
Refer to Tightening torque for major components in page11.



3. ELECTRICAL COMPONENTS

Before removing each component, disconnect cables and earth lines attached to the component.

REMOVAL



1) Battery

Battery can be replaced using Forklift, Pallet truck or exclusive jig. Make sure max capacity of the Forklift or Pallet truck is above the battery weight.

- ▲ Using improper method may result in battery tip over accident so be cautious.
- ▲ Change battery on flat ground.
- ▲ Battery might fall off if equipment tip over while battery locking device is loose. Always operate equipment with battery locked.

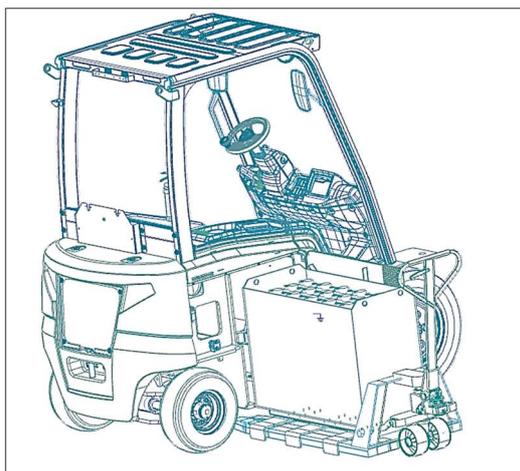
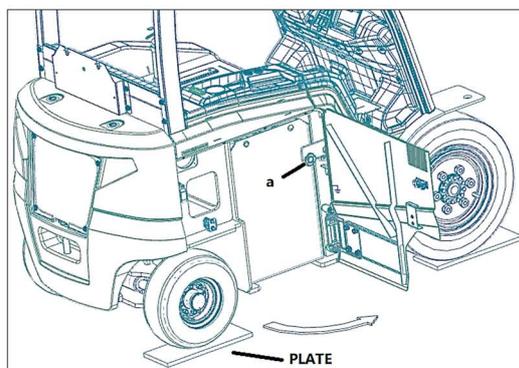
- ① Park the truck horizontally and with 140mm or more road clearance, turn the engine off and open the right battery door. Then disconnect the connector and unlock battery locking device (a)

- ※ Make sure road clearance is over 140 mm by placing plate (10~20t) under front and rear wheels.

- ※ If manual unlocking procedure is impossible due to battery being too close to the locking device, push the battery in slightly with fork then unlock the locking device.

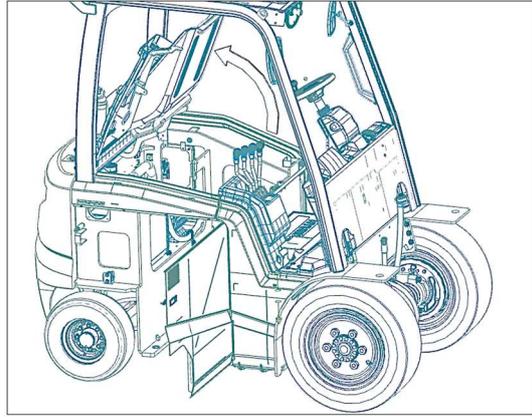
- ② Place fork in a way that battery sits balanced, carefully remove battery from the frame.

- ※ When carrying the battery, slow maneuver is required.

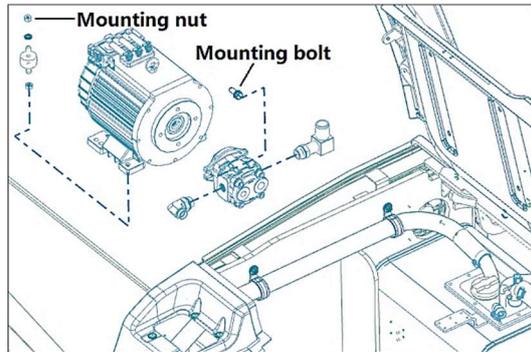


2) Pump Motor

- ① Lower the fork to floor.
Push the joystick to lower the fork and tilt forward to the ground.
- ② Remove the battery.
- ③ Open the battery cover.



- ④ Remove pump motor, gear pump, wiring for priority valve, rubber hose and hydraulic hose.
- ⑤ Loosen mounting nut and remove pump motor, gear pump, priority valve from the frame.
- ⑥ Loosen mounting bolt and remove priority valve and pump motor.

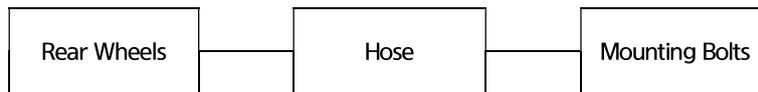


INSTALLATION

Installation is the reverse order of removal. Refer to Tightening torque for major components in 1-8.

4. STEERING AXLE

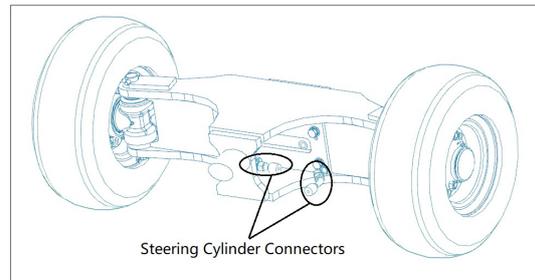
REMOVAL



1) Rear Wheel

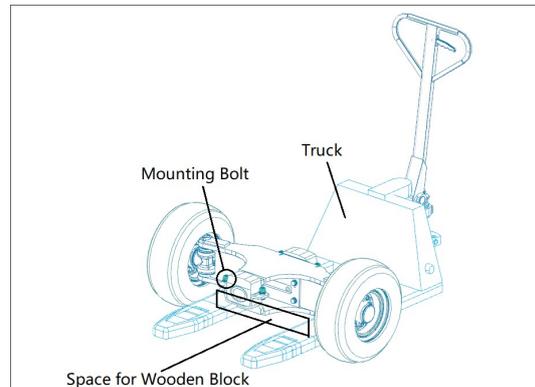
2) Hose

Disconnect the hoses from the steering axle.



3) Mounting Bolt

Put a block between the steering axle and support of truck, and raise the frame with a crane. Remove the mounting bolts installing to the frame, and pull out to the axle.

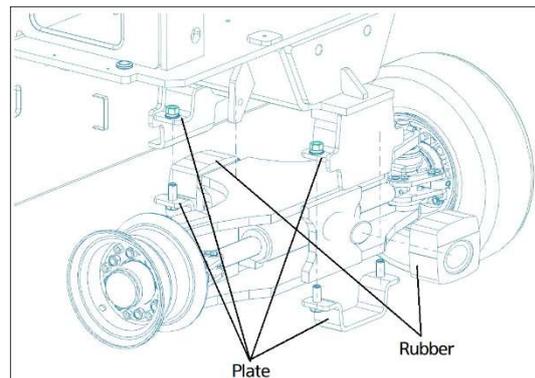


INSTALLATION

1) Mount two rubbers on the steering axle. The rubber is not symmetrical and make sure the hole is in the lower position.

2) Lubricate bolts with Loctite 277.

3) Mount the bolts, spring washers and nuts, make sure nuts are on the top. Tighten torque should be 29.5 ± 0.5 kgf-m.



GROUP 3 MAINTENANCE FOR HOSE

1. MAINTENANCE

The function and service life of hydraulic components depend to a great extent on how they are maintained regularly. Therefore, it is very important to prevent dirt from entering the hydraulic system.

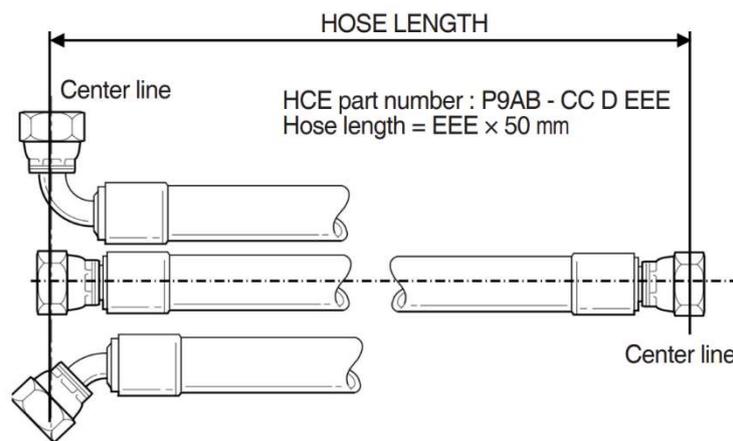
Some simple advice to keep the hydraulic system clean:

- Always clean the area around parts before starting work. If possible, it is better to wash the truck.
- Plug hose connections immediately after disconnecting. If possible, use correct plugs for the connection type. If plugs do not match, use clean plastic bags and cable ties or tape to seal the connection.
- Never reuse oil that has been drained from the truck.
- If possible, filter the oil before pouring it into the truck, oil barrels often contain impurities.

2. HOSE LENGTH

Connected hoses have HCE part number, but if they have no information the hoses are measured as follows:

- The hose length is measured on a laid-out hose between the sealing surfaces
- On angled connections, measure from the sealing surface's center line according to the figure.



3. CAUTION FOR REPLACEMENT

When replacing hoses for maximum service life and functionality, the following must be observed:

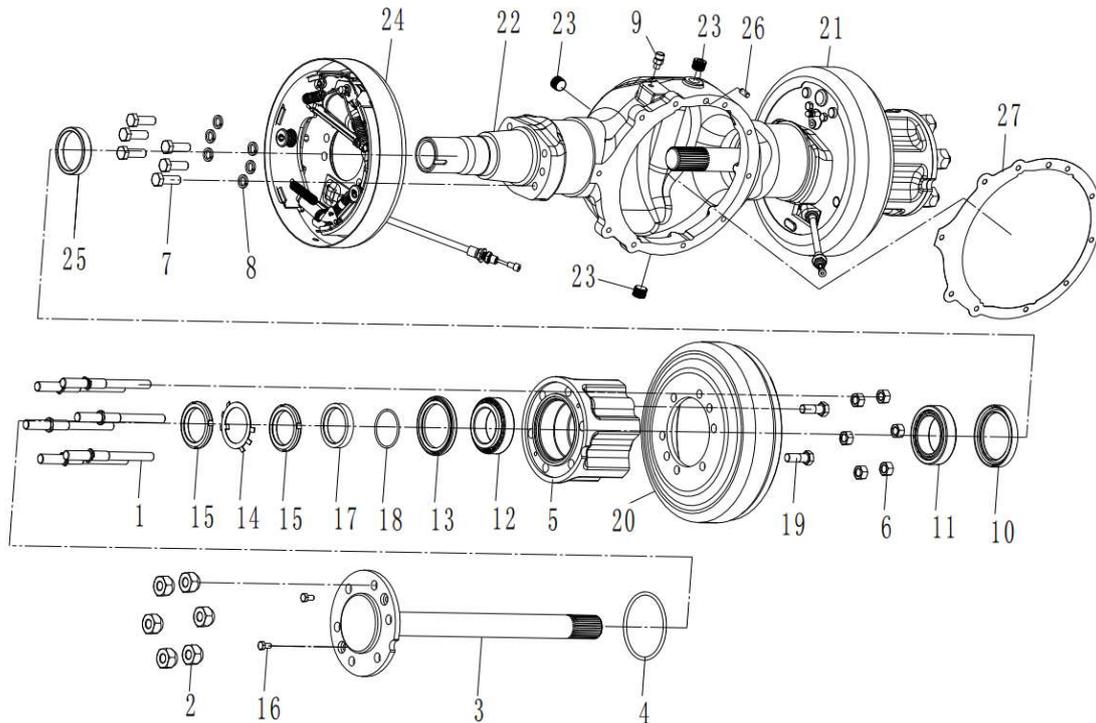
- To avoid stress when connecting, a straight hose length must be secured after connection.
- Do not kink the hose. 7% twist reduces the service life by 90%.
- Do not use hoses that are too short. It may cause leakage or damage
- Use the correct coupling to minimize the number of bends.
- Avoid sharp bending.
- When storing, keep the inside of the hose clean. When installing, keep the connector in place for as long as possible.

SECTION 3 POWER TRAIN SYSTEM

GROUP 1 STRUCTURE AND OPERATION

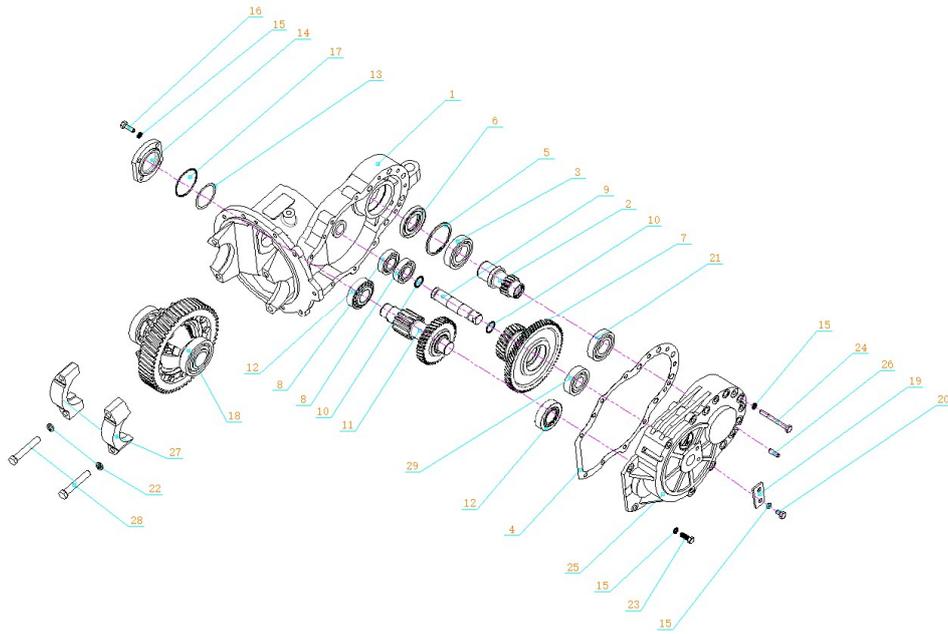
1. STRUCTURE

1) Drive Axle

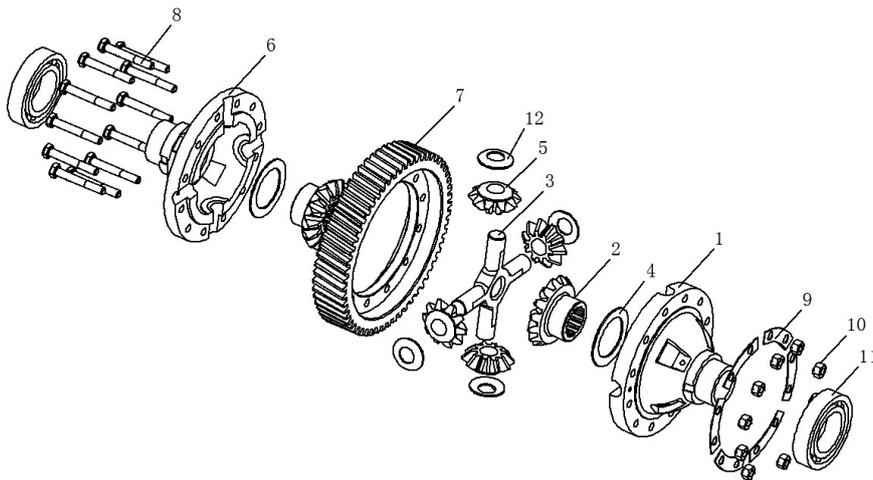


1	Bolt-Hub	10	Oil Seal	19	Bolt
2	Nut-Hub	11	Bearing	20	Brake Drum
3	Axle Shaft	12	Bearing	21	RH Brake Assy
4	O-Ring	13	Oil Seal	22	Housing-Axle
5	Hub	14	Ring-Stop	23	Plug
6	Nut	15	Nut	24	LH Brake Assy
7	Bolt-Brake Assy	16	Bolt	25	Ring-Seal
8	Spring Washer	17	Ring-Retain	26	Pin
9	Plug-Breath	18	O-Ring	27	Gasket-Axle Shaft

2) Transmission



1	Body	11	Gear Assy	21	Bearing
2	Input Shaft Assy	12	Bearing	22	Washer-Spring
3	Bearing	13	Shim	23	Bolt
4	Gasket	14	Cover-Bearing	24	Bolt
5	Ring-Block	15	Washer-Spring	25	Cover-Body
6	Oil Seal	16	Bolt	26	Pin
7	Gear Assy	17	O-Ring	27	Bearing Seat
8	Bearing	18	Differential Assy	28	Bolt
9	Shaft	19	Block	29	Bearing
10	O-Ring	20	Bolt		



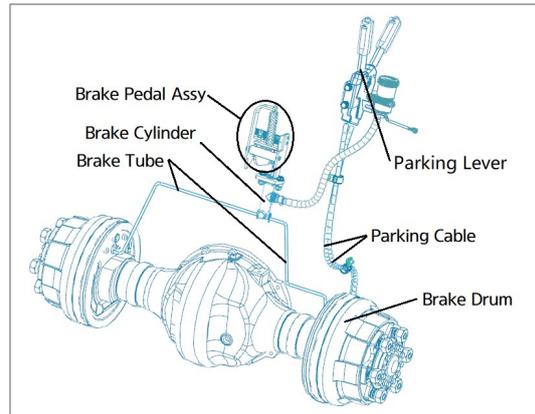
Differential

1	Housing-LH	5	Planetary Gear	9	Plate-Lock
2	Axle Shaft Gear	6	Housing-RH	10	Nut
3	Cross Axle	7	Gear Ring	11	Bearing
4	Washer	8	Bolt	12	Washer-Block

2. OPERATION

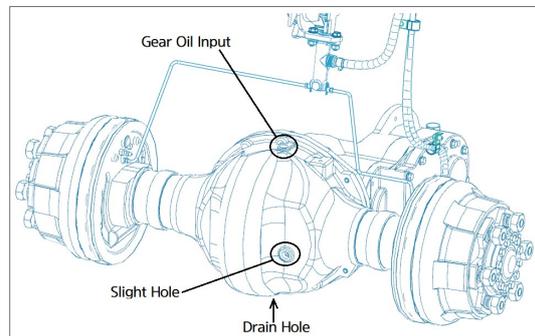
The drive axle and the transmission transmit the power from motor to drive wheels.

Service brake and parking brake will affect brake drum by brake tube and parking cable, and work in dry mode.



Add gear oil

- 1) Remove the bolts in sight hole and oil input.
 - 2) Add the gear oil in oil input until the oil level rise to the sight hole which means the oil level can be observed from sight hole.
 - 3) Mount two bolts.
- ※ Do not spill gear oil on the floor, or discharge it into drain.



3. SPECIFICATIONS

Drive Axle

Item	Unit	Specifications
Rated axle load	Kg	5000
Weight (excluding oil)	Kg	118
Gear oil volume	L	3.5

Transmission

Item	Unit	Specifications
Gear ratio	-	25.047
Transmission efficiency	-	≥90%
Noise	dB(A)	≤80
Max. input speed	Rpm	3300

GROUP 2 FAILURE DIAGNOSIS AND CORRECTIVE ACTIONS

Drive axle

Trouble		Cause	Corrective action
Oil leak	Oil seal	<ul style="list-style-type: none"> · O-ring or ring-spring broken · Oil seal broken 	<ul style="list-style-type: none"> · Replace · Replace
	Outer of axle shaft	<ul style="list-style-type: none"> · Bolt loose · Gasket-axle shaft broken 	<ul style="list-style-type: none"> · Tighten, torque 230Nm · Replace
	Axle Body	<ul style="list-style-type: none"> · The bottom plug loose 	<ul style="list-style-type: none"> · Tighten, replace parts if required
	Connection of axle and T/M	<ul style="list-style-type: none"> · Gasket broken · Bolt loose 	<ul style="list-style-type: none"> · Replace · Tighten, replace parts if required
Noise	Bearing	<ul style="list-style-type: none"> · Space between bearings is too big · Bearing broken 	<ul style="list-style-type: none"> · Remount the axle shaft assy · Replace

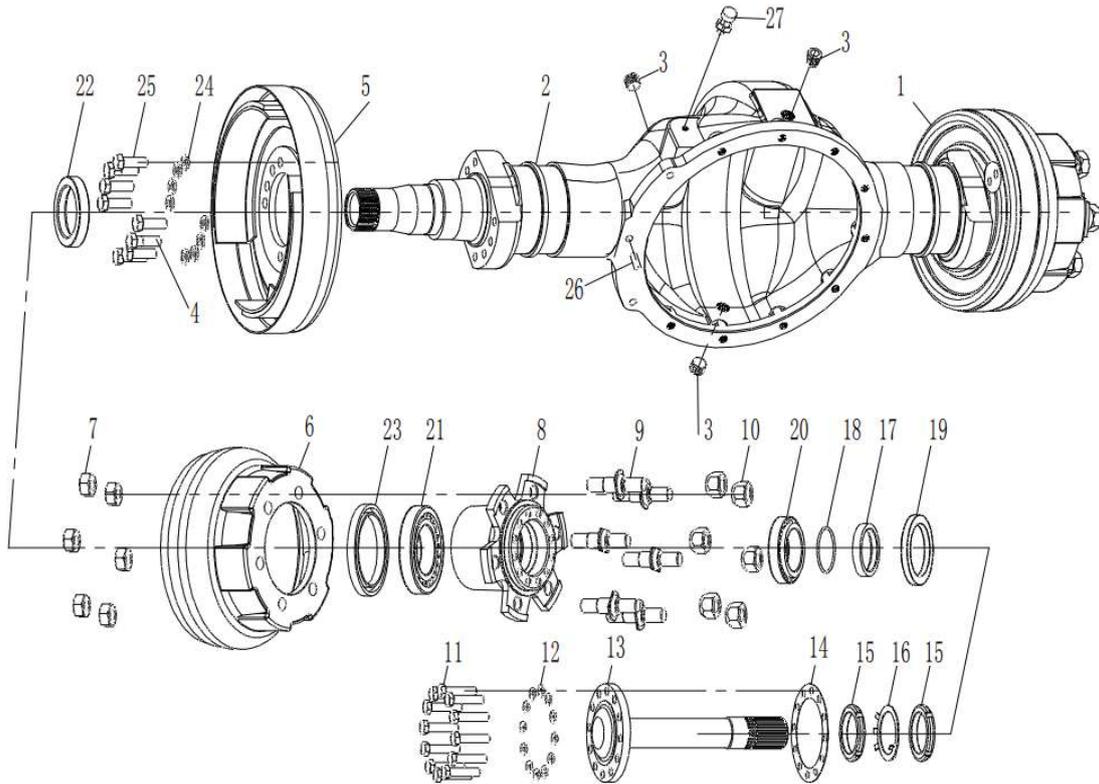
Transmission

Trouble		Cause	Corrective action
Oil leak	Input shaft	<ul style="list-style-type: none"> · Oil seal broken · Input shaft cover loosen 	<ul style="list-style-type: none"> · Replace the oil seal, check the shaft for scratches, replace the shaft if there are scratches · Apply sealant on the outer circle of the cover
	Middle shaft	<ul style="list-style-type: none"> · O-ring broken 	<ul style="list-style-type: none"> · Replace
	Body cover	<ul style="list-style-type: none"> · Gasket broken 	<ul style="list-style-type: none"> · Replace
	Bearing cover-gear shaft	<ul style="list-style-type: none"> · O-ring broken · Slot of O-ring is too deep 	<ul style="list-style-type: none"> · Replace · Replace the cover
Noise	Periodic noise	<ul style="list-style-type: none"> · There are scratches or bumping on tooth surface of gear 	<ul style="list-style-type: none"> · Polish the protruding point above the tooth surface.
	Big noise in reduce	<ul style="list-style-type: none"> · Lack of oil · Bearing broken · Gear in reduce broken 	<ul style="list-style-type: none"> · Add · Replace · Replace gear ring
Truck cannot move	Differential	<ul style="list-style-type: none"> · Connect bolts broken 	<ul style="list-style-type: none"> · Replace

GROUP 3 DISASSEMBLY AND ASSEMBLY

DRIVE AXLE

Disassembly



- 1) Disassemble the bottom and top plug (23#) to drain gear oil.
 - 2) Remove the bolt (16#) to disassemble the axle shafts.
 - 3) Remove nuts (15#) and ring-stop (14#), then disassemble brake drum (20#).
 - 4) Remove nuts (6#) to disassemble hub (5#) from brake drum (20#).
 - 5) Remove ring-seal (25#) and bolts-brake assy (7#) to disassemble brake assy (24#).
- ※ Care should be exercised to protect O-ring and bearings.
※ Store LH and RH axle shafts respectively.

Assembling is the reverse order of removal and for more details please refer disassemble in next page.

Assembling

- 1) Mount outer ring of bearing (12#) into hub (5#) with a fixture.



- 2) Mount outer ring of bearing (11#) into hub (5#) with a fixture.



- 3) Apply lithium base grease on inside of hub (5#) until 1/3-1/2 of inside surface is applied.



- 4) Mount inner ring of bearing (11#) into hub (5#).



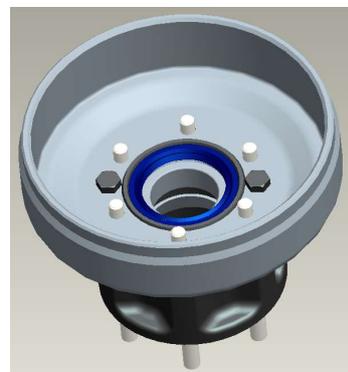
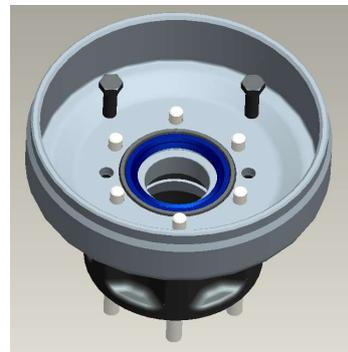
5) Mount oil seal (10#) into hub (5#).



6) Mount bolt (1#) × 6 in Hub (5#).



7) Mount hub (5#) and brake drum (20#) together. Then install the set bolt (19#) × 2 with Loctite 242.
Fastening torque: 23 kgf·m



8) Lubricate bolt (1#) × 6 with Loctite 242.



9) Mount bolt (6#).
Fastening torque:22 kgf·m



10) Lubricate housing-axle (22#) in mounting position of ring-seal (25#) with sealant.



11) Mount the ring-seal (25#) on housing-axle (22#) with a fixture.



- 12) Lubricate housing-axle (22#) in mounting position of brake
assy (24#) with sealant



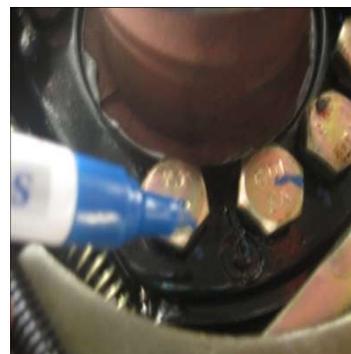
- 13) Mount brake assy (24#) and housing-axle (22#) together.



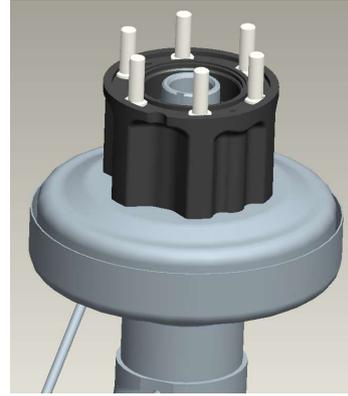
- 14) Lubricate bolt-brake assy (7#) × 6 with Loctite 242.



- 15) Mount the bolt-brake assy (25#) × 6 and remark.
Fastening torque:21-23 kgf.m



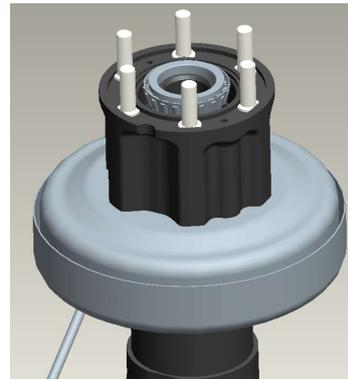
16) Mount brake drum (20#) and housing-axle (22#) together.



17) Knock the brake drum (20#) with copper rod to ring-seal (25#) match up oil seal (10#).



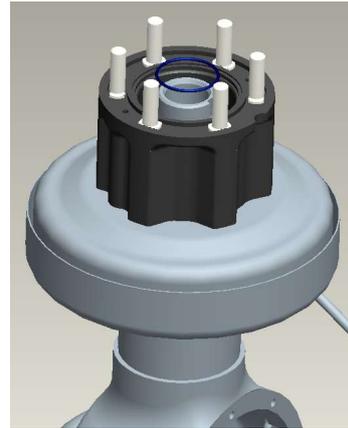
18) Lubricate inner ring of bearing (11#) with grease.



19) Mount inner ring of bearing (11#) into hub (5#).



20) Mount the O-ring (18#) into hub (5#).



21) Mount the ring-retain (17#) into hub (5#).



22) Lubricate outside of oil seal (13#).



23) Mount the oil seal (13#) into hub (5#) with a fixture.



24) Mount the nut (15#) with a fixture. After tightening the nut, brake drum cannot rotate freely, then return the nut 1/8-1/6 circle.

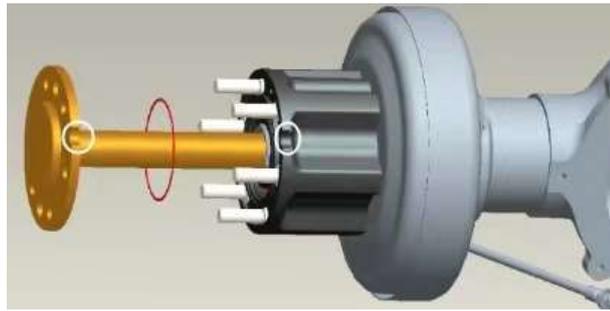
Check if the start torque of hub is 7-15 kgf-m. If not, adjust the nut.



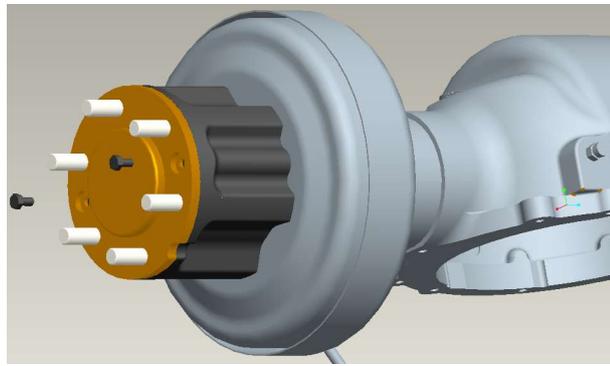
25) Mount the ring-stop (14#)



26) Mount the O-Ring (4#) and Axle Shaft (3#), the notch should align at another notch.

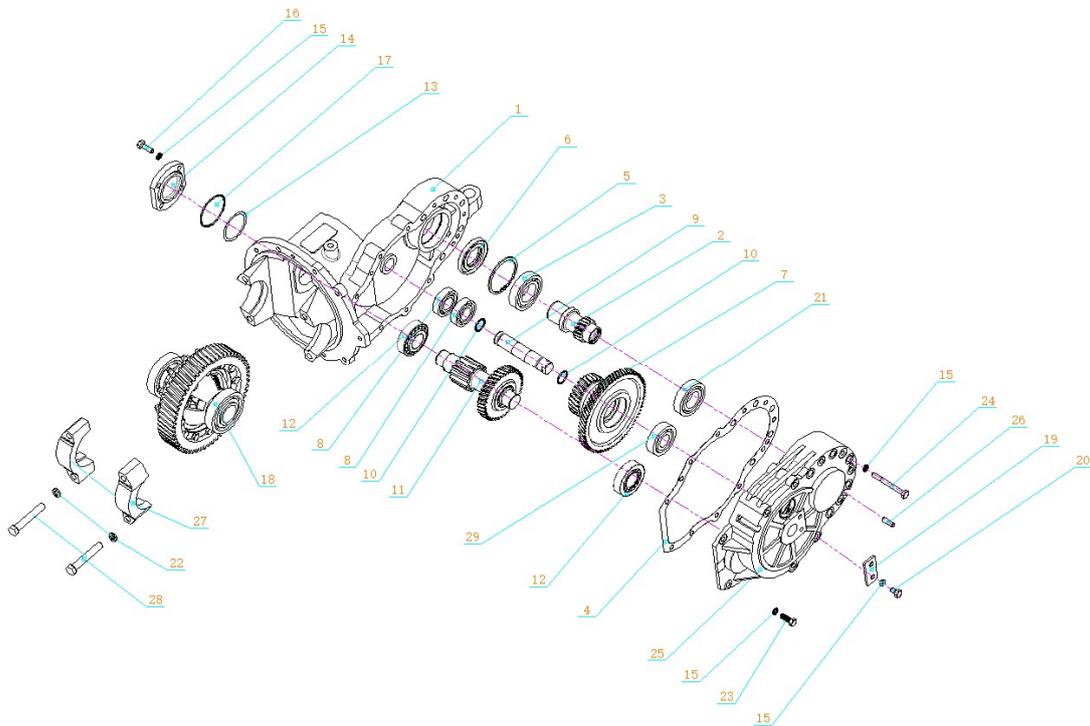


27) Mount the bolt x 2 (16#).
Fastening torque: 2.5 kgf.m



Transmission

Disassembly

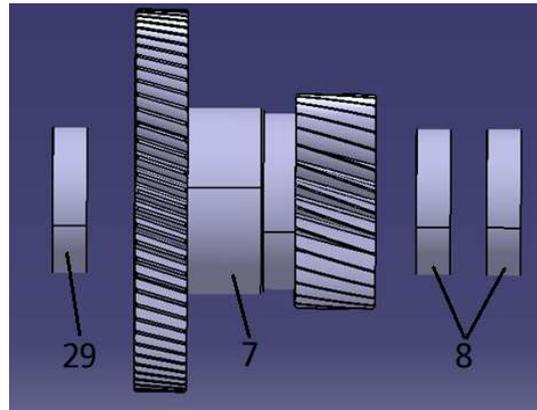


- 1) Remove bolts (28#) to disassemble the differential.
 - 2) Remove oil seal and ring-block to disassemble input shaft assy.
 - 3) Remove bolts (20#) to disassemble the shaft (9#).
 - 4) Remove bolts (24#) and bolts (23#) to disconnect body (1#) and cover (25#).
 - 5) Remove shaft (9#) and two gear assy (7#/11#).
- ※ Care should be exercised to protect O-ring, gasket and bearings.

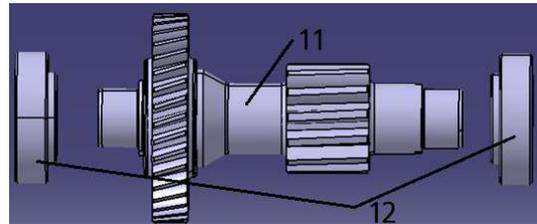
Assembling is the reverse order of removal and for more details please refer disassemble in next page.

ASSEMBLING

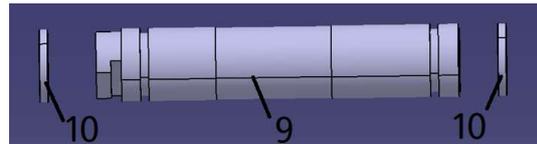
- 1) Part 1: Mount the bearing (8#) × 2 and bearing (29#) in the gear assy (7#).



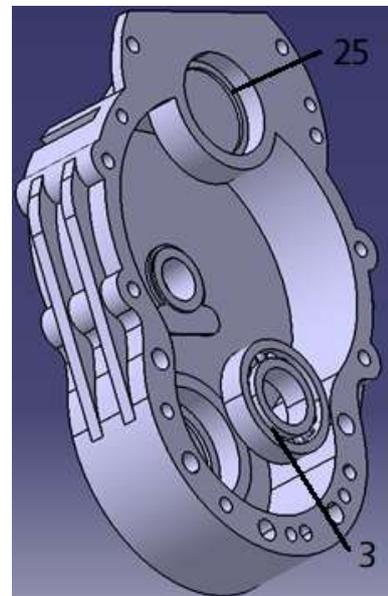
- 2) Part 2: Mount the bearing (11#) × 2 in the gear assy (12#).



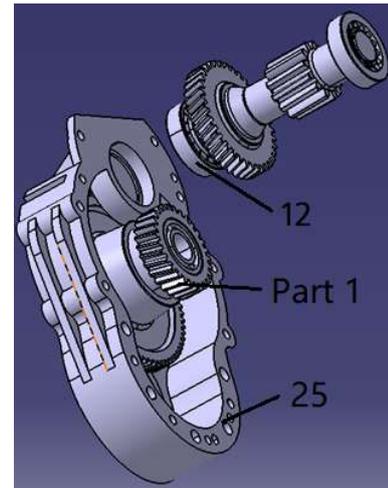
- 3) Part 3: Mount the O-ring (10#) × 2 on the shaft (9#).



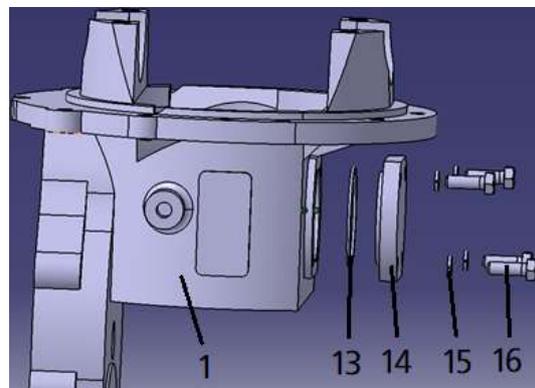
- 4) Mount the bearing (3#) in cover-body (25#).



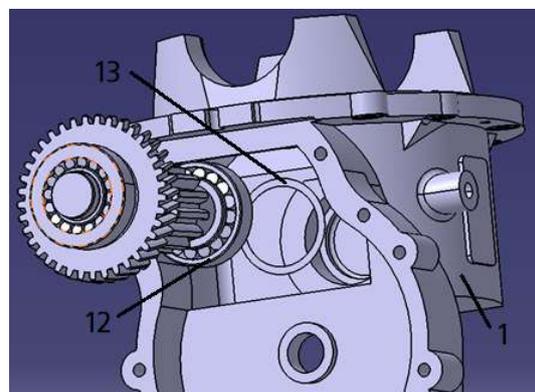
- 5) Mount the part 1 and the outer ring of bearing (12#) in cover-body (25#).



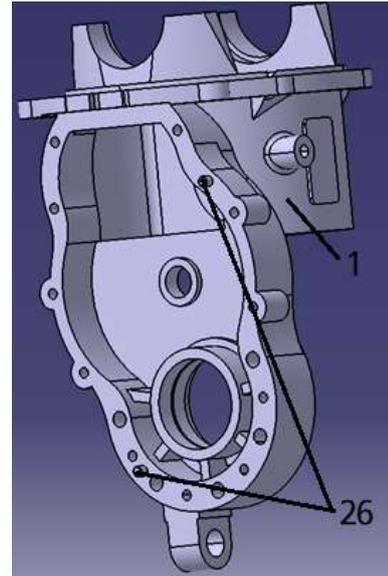
- 6) Mount the O-ring (13#), cover-bearing (14#), washer-spring (15#) × 4 and bolt (16#) × 4 on body (1#).



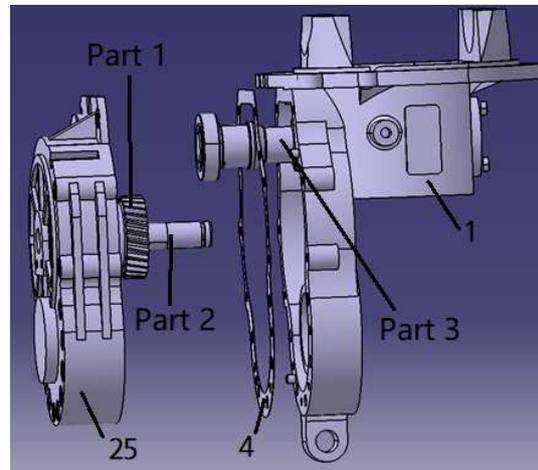
- 7) Mount the outer ring of bearing (12#) and washer (13#) in body (1#).



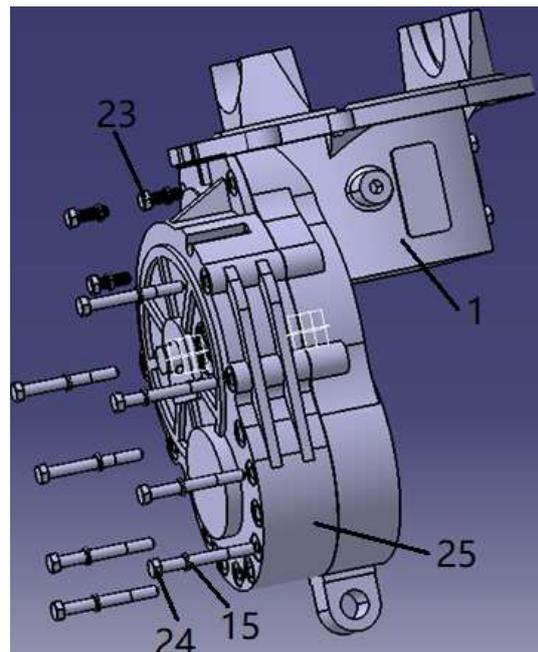
8) Mount the pin (26#) × 2 in body (1#).



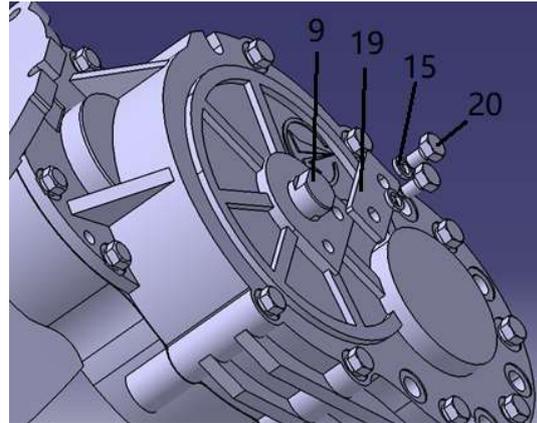
9) Mount part 1, part 2 and part 3 and gasket (4#) in body (1#) and cover-body (25#).



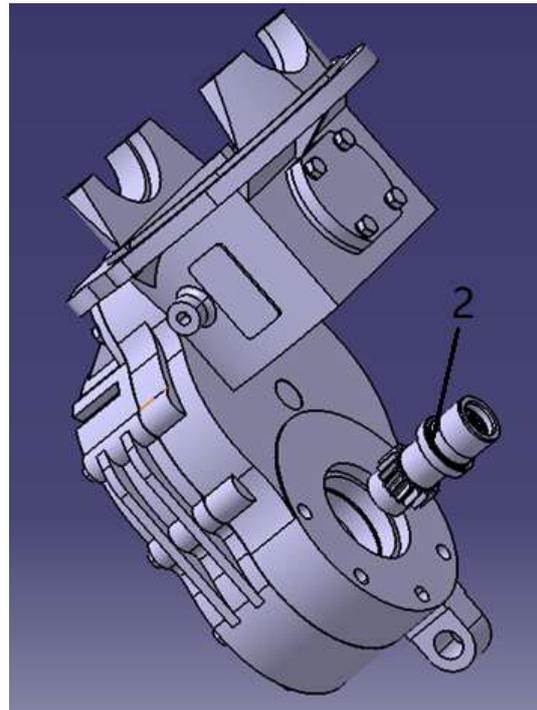
10) Mount body (1#) and cover-body (25#) with washer (15#) × 11, bolt (24#) × 8 and bolt (23#) × 3.



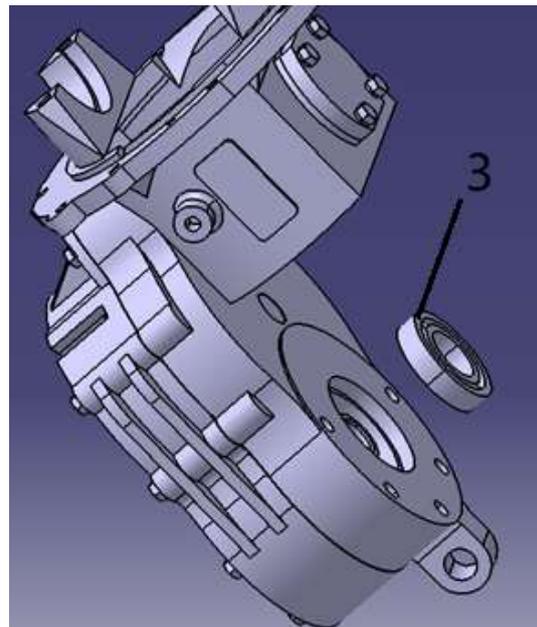
- 11) Mount the shaft (9#) and block (19#) as shown in photo with bolt (20#) × 2 and washer (15#) × 2.



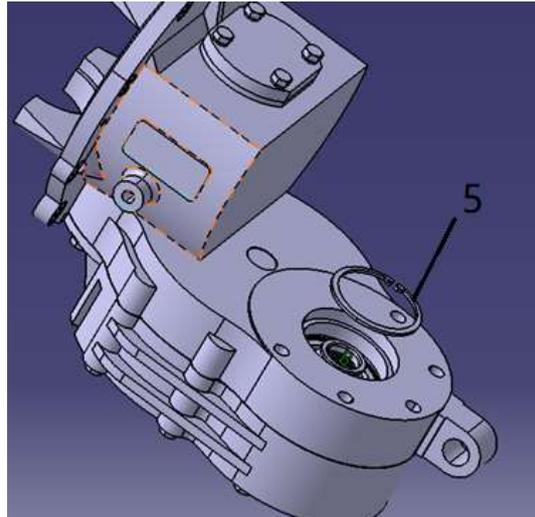
- 12) Mount the input shaft assy (2#).



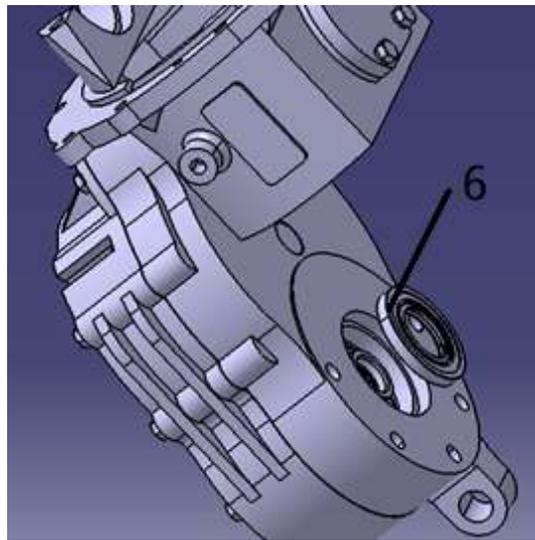
- 13) Mount the bearing (3#).



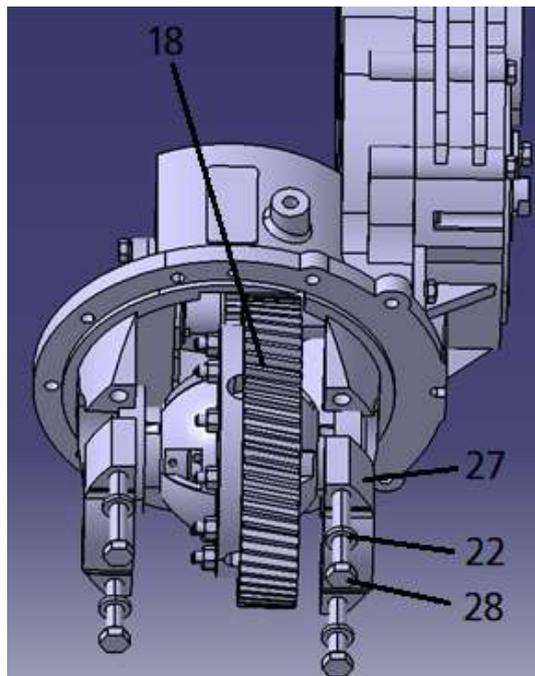
14) Mount the ring-block (5#).



15) Mount the oil seal (6#).



16) Mount the differential (18#) with boss-bearing (27#) \times 2, spring lock washer (22) \times 4 and bolt (28) \times 4.



SECTION 4 BRAKE SYSTEM

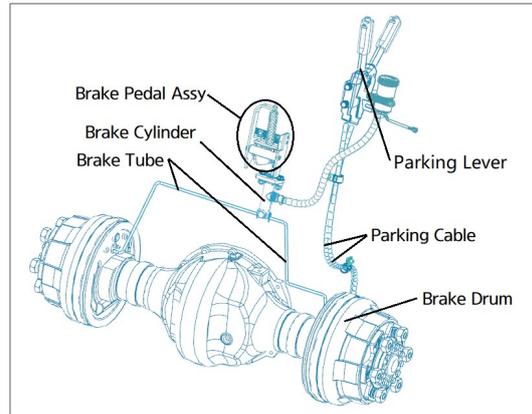
GROUP 1 STRUCTURE AND FUNCTIONS

1. INTRODUCTION

There are two types of brake systems: Service brake and parking brake.

Pressing the service brake pedal generates hydraulic pressure in the master cylinder. This pressure lets the brake lever press the pressure pin to apply braking pressure on the disk carrier.

The parking brake lever operates with cable to make the pressure pin apply braking pressure on the disk carrier



2. SPECIFICATIONS

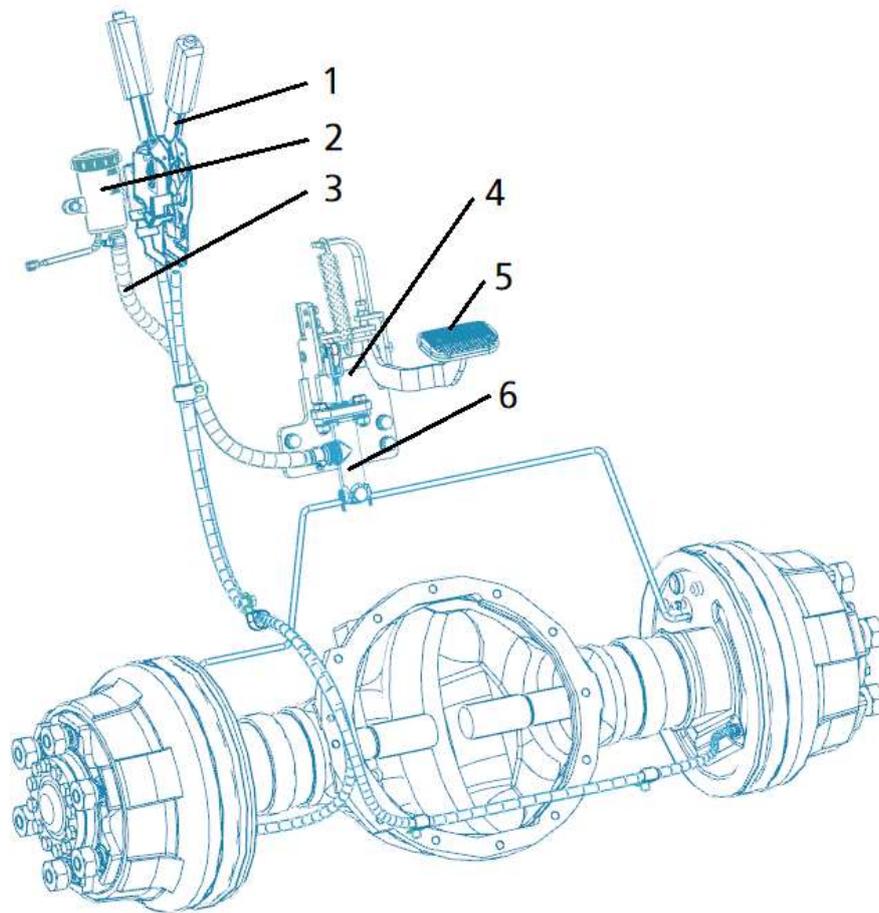
1) SERVICE BRAKE

Item	Specifications
Type	Front-wheel mounted, dry disk mode
Brake Oil	Dot 3

2) PARKING BRAKE

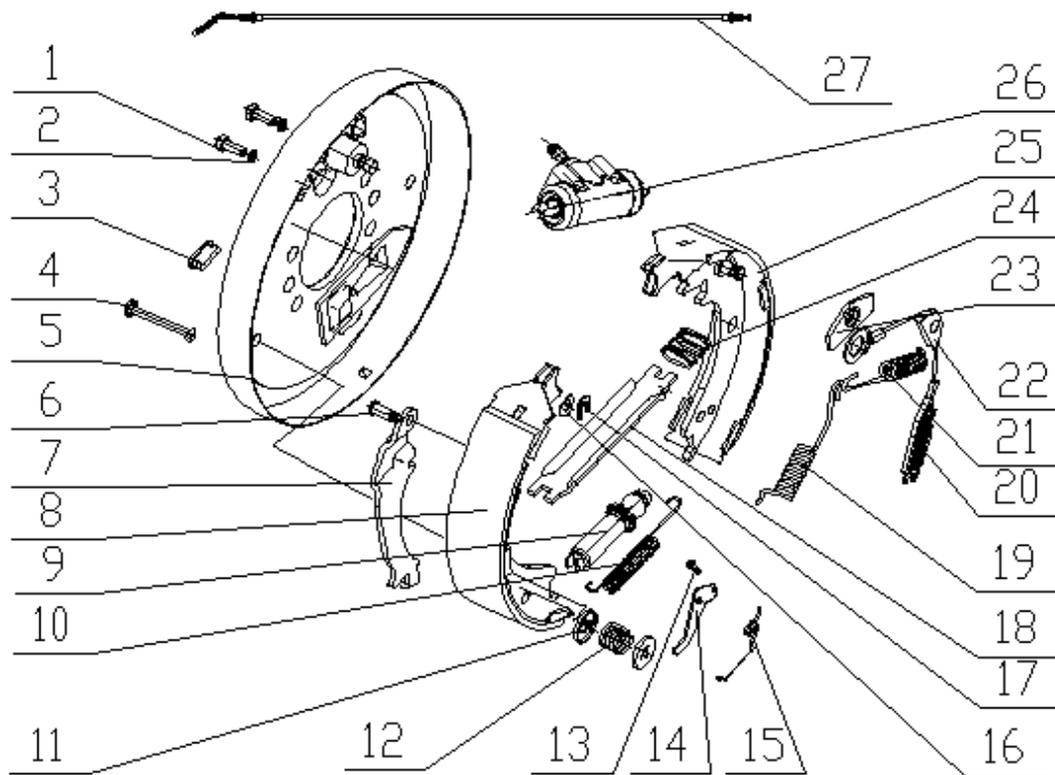
Item	Dimensions
Type	Mechanical
Parking lever stroke	48.3 deg.

3. BRAKE PEDAL AND PIPING



- | | | | |
|---|---------------------|---|----------------|
| 1 | Parking Brake Lever | 4 | Bracket |
| 2 | Reserve Tank | 5 | Brake Pedal |
| 3 | Hose | 6 | Brake Cylinder |

4. BRAKE DRUM



1 Bolt	10 Spring-Tension	19 Spring-Return
2 Washer-Spring	11 Boss-Spring	20 Spring Assy
3 Plug	12 Spring-Compress	21 Spring-Return
4 Rod-Spring	13 Pin	22 Block-Guide
5 Plate Assy	14 Pawl	23 Plate-Guide
6 Pin	15 Spring-Torsional	24 Spring
7 Rod-Parking	16 Washer-Spring	25 Brake Pad & Pin Assy
8 Brake Pad Assy	17 Ring-Retainer	26 Slave Pump
9 Gap Adjustment	18 Rod-Parking	27 Cable Assy RH/1650mm Cable Assy LH/1200mm

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

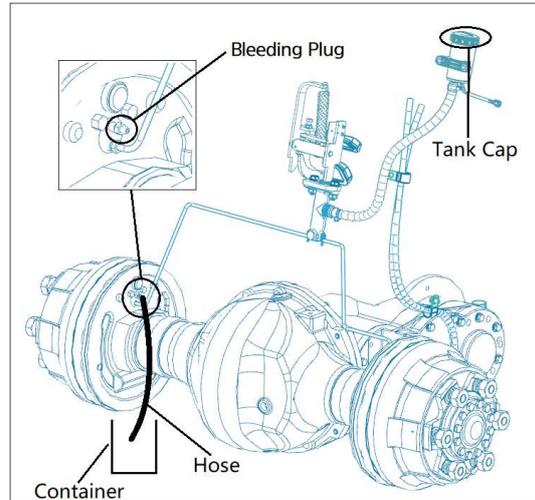
Trouble		Cause	Corrective action
Brake perform bad	Brake drum	· Space between brake pad assy and brake drum is too big	· Adjust
	Oil leak	· Connector loose	· Tighten the connector, replace parts if required
	Air in system	· Air in system · Connector loose	· Fully bleed the system. · Tighten the connector, replace parts if required
No brake	Brake drum	· Brake pad assy reach the limit of life	· Replace
	Hub oil seal	· Oil seal broken, oil flow into brake drum.	· Replace the oil seal and clean brake drum, replace parts if they cannot be cleaned.
	Slave Pump	· Oil leak, oil flow into brake drum	· Replace slave pump assy and clean brake drum, replace parts if they cannot be cleaned.
Always brake	Brake drum	· Space between brake pad assy and brake drum is too small	· Adjust

GROUP 3 TESTING AND ADJUSTMENT

1. BRAKE BLEEDING

Bleeding should be performed on brake system after filling brake oil.

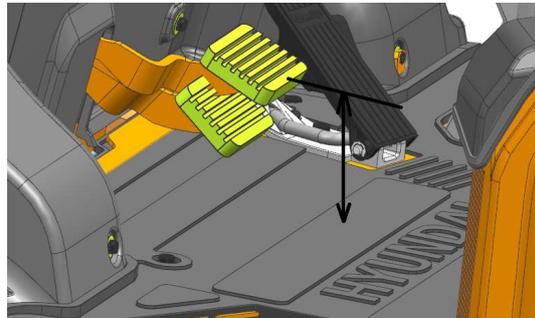
- 1) Unscrew (not remove) the nut in the plug, and connect a hose to put discharging fluid into a container.
- 2) Press brake pedal to apply pressure.
- 3) Continue to loosen the nut until oil flows out while pressing brake pedal to bleed the brake oil.
 - ※ Put discharged brake fluid into a container.
 - ※ Do not spill brake fluid on the floor, or discharge it into drain.
 - ※ Repeat this process until brake fluid shows no bubble.
 - ※ Check the level of brake oil in the tank, and fill the brake oil, if required.
- 4) Once brake oil is discharged without indication of bubble, remove hose, fasten the plug, and install dust prevention cap on the plug.



2. BRAKE PEDAL

Adjust the height of pedal from the floor plate with a stopper bolt.

- Pedal height: 90 mm



3. BRAKE SYSTEM

The brake system does not need maintenance, except after replacing the friction plate. Please adjust the braking system in the following order.

1) Brake Drum

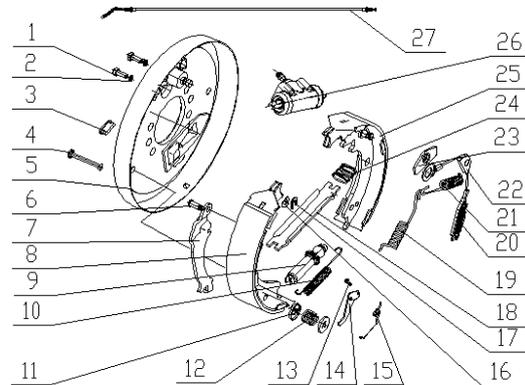
Brake drum does not need to be adjusted unless the brake pad assy (8#) has been replaced. The distance between pad assy (8#) and plate assy (5#) should be 0.25-0.4mm.

Distance is too big:

- ① Remove the rubber plug.
- ② Pull down the gap adjustment gear (9#) until the pawl (14#) slip.
- ③ Mount the rubber plug.

Distance is too small:

- ① Remove the rubber plug.
- ② Push the pawl (14#) away by a screwdriver
- ③ Pull up the gap adjustment gear (9#) until the distance is in range.
- ④ Mount the rubber plug.



2) Running-in

After changing the friction plate, it is necessary to run 500-800 circles in order to increase the contact area between the friction plate and brake drum.

There are two ways to run-in:

- ① When the front wheels are off the ground, press accelerator pedal and brake pedal at the same time. Repeat the process for a total of 2-3 minutes for one side.
- ② Repeat going frontward and backward. When the speed is at 15Km/h, press the brake pedal to slow down to 10~12Km/h and drive for 1-2 seconds. Then change the direction. Repeat the process for a total of 2-3 minutes.

※ When there is only one brake drum is well-adjusted, jack this side and press accelerator pedal and brake pedal at the same.

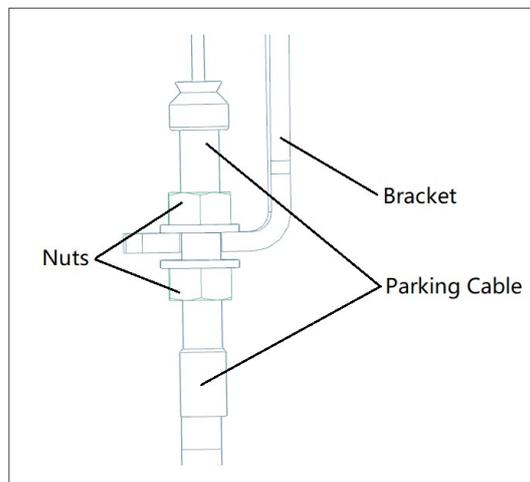
▲ When running-in, pay attention to prevent accidental intrusion.

3) Parking Brake

There are two parking cables that control LH/RH.

Move the parking cable up or down to adjust parking brake force by adjusting two nuts at the same time.

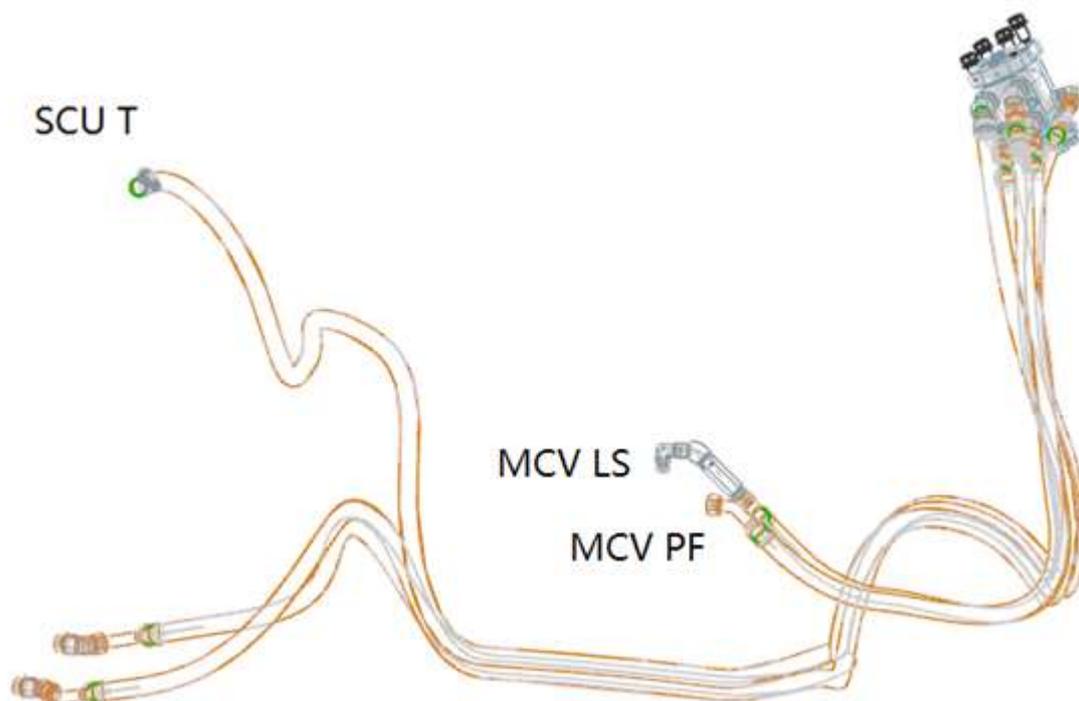
▲ Make sure the brake system work properly before the truck is operated.



SECTION 5 STEERING SYSTEM

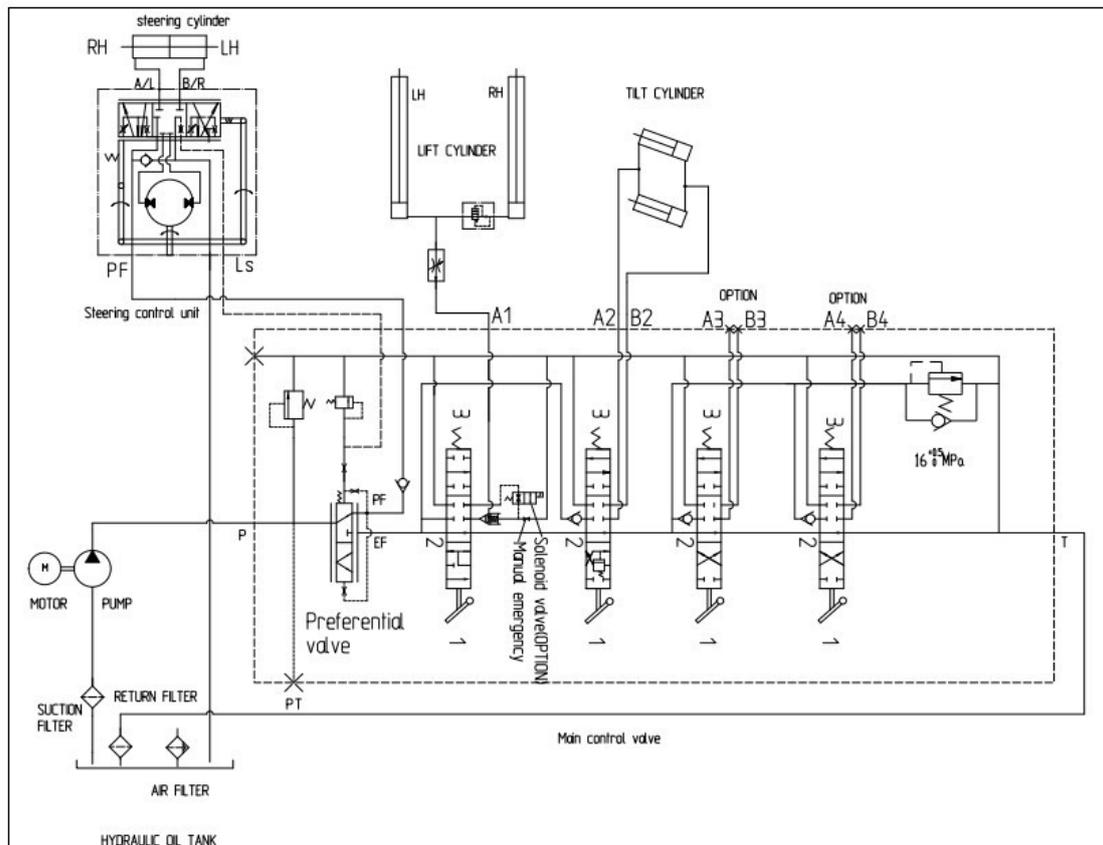
GROUP 1 STRUCTURE AND FUNCTIONS

1. INTRODUCTION



Steering system consists of hydraulic pump, steering wheel assembly, steering unit, preferential valve, steering cylinder, and piping. Steering axle with integrated rear wheel tire and cylinder supports the weight of forklift truck. Steering axle is of structure with steering knuckles installed on the both sides of king pin. Hubs and wheels are fastened on spindles of knuckles. When turning steering wheel to move forklift truck to the left or right, rotational torque is transferred to steering unit, and hydraulic oil in steering unit flows to steering axle hydraulic cylinder through hose. Force generated from steering cylinder moves knuckle of rear wheel through intermediate link. See the figure for locations of steering system components.

2. HYDRAULIC CIRCUIT



Hydraulic oil is supplied from hydraulic pump to preferential valve. When driver turns steering wheel, hydraulic oil is supplied first to steering unit by working circuit inside preferential valve. Hydraulic oil inside steering unit is expanded or shrunk, and then supplied to steering cylinder of forklift truck. hydraulic oil excessively discharged from hydraulic pump flows to hydraulic oil tank along main control valve and preferential valve EF port.

1) NEUTRAL

When hydraulic motor starts operating, and steering wheel is kept in neutral position, steering unit spool and sleeve are kept in neutral position. Flow of hydraulic oil through valve is blocked to the left and right steering ports. Pressure on pilot of preferential valve spool controls spool to move it to the opposite direction. Hydraulic oil flows to main control valve through EF port with this type of control. Small quantity of hydraulic oil in neutral position is continuously discharged through orifice. Hydraulic oil flows in through LS hose piping, and then is discharged to hydraulic oil tank through steering unit spool and sleeve. Upon sudden steering, dynamic flow of hydraulic oil prevents initial hard spot.

2) TURNING LEFT OR RIGHT

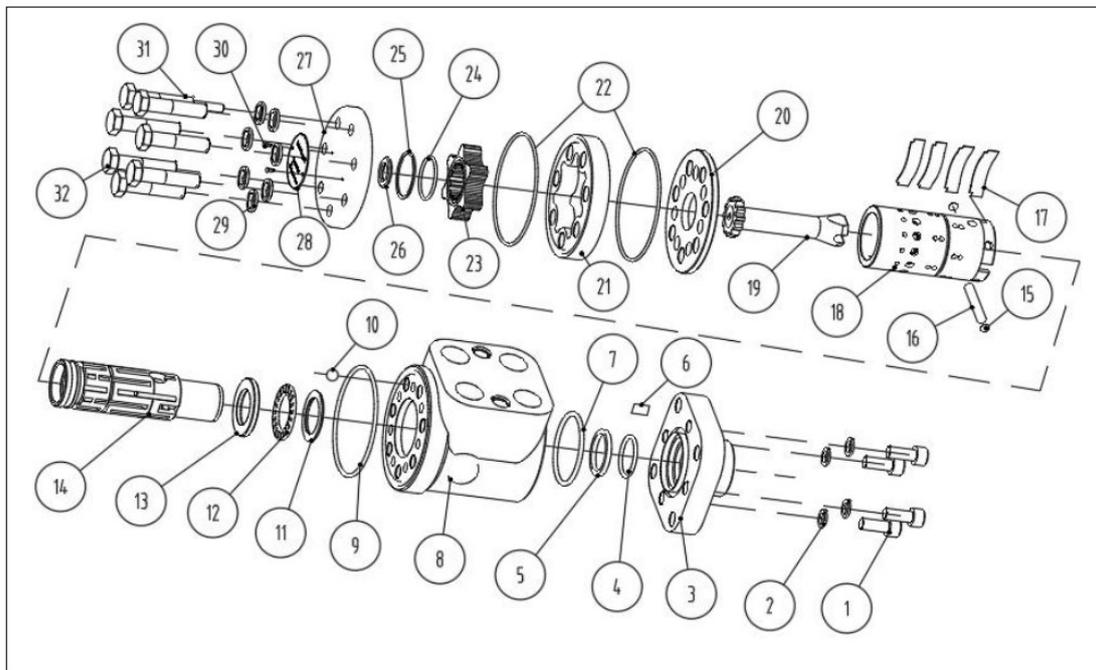
When hydraulic motor starts operating, and steering wheel is turned, steering unit spool and sleeve rotate. Path opens to allow supply of hydraulic oil to gear inside steering unit. Hydraulic oil causes rotation of pump. Hydraulic oil returns to steering valve spool and sleeve, and is supplied to left or right steering cylinder port by turning of steering wheel. LS port circuit is connected to PF port, which blocks return of hydraulic oil to hydraulic oil tank, and senses pressure required for turning of steering

wheel. When pressure required for LS circuit increases or decreases, preferential valve spool moves to satisfy conditions of hydraulic oil and pressure required for rotating tires. Once steering cylinder reaches the maximum stroke, relief valve supplies hydraulic oil to hydraulic oil tank to adjust pressure. Preferential valve spool moves to supply hydraulic oil to main control valve through EF port.

When the vehicle turns right (R), the steering wheel rotates clockwise, the steering gear works right, the B port is under high pressure, and the steering cylinder is connected to the left chamber (LH). The same is true for vehicles turning left.

3. STEERING UNIT

1) STRUCTURE

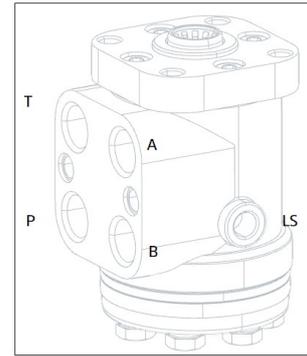


1	Screw	12	Bearing	23	Rotor
2	Washer-Spring	13	Washer	24	O-Ring
3	Cover-Front	14	Element-Valve	25	Ring-Slide
4	O-Ring	15	Washer	26	Pin
5	X-ring	16	Pin	27	Cover-Rear
6	Sleeve-Thread	17	Plate-Spring	28	Nameplate
7	O-Ring	18	Sleeve-Valve	29	Washer
8	Body-Valve	19	Shaft	30	Rivet
9	O-Ring	20	Plate-Separate	31	Bolt-Retain
10	Steel Ball	21	Stator	32	Bolt
11	Ring-Retain	22	O-Ring		

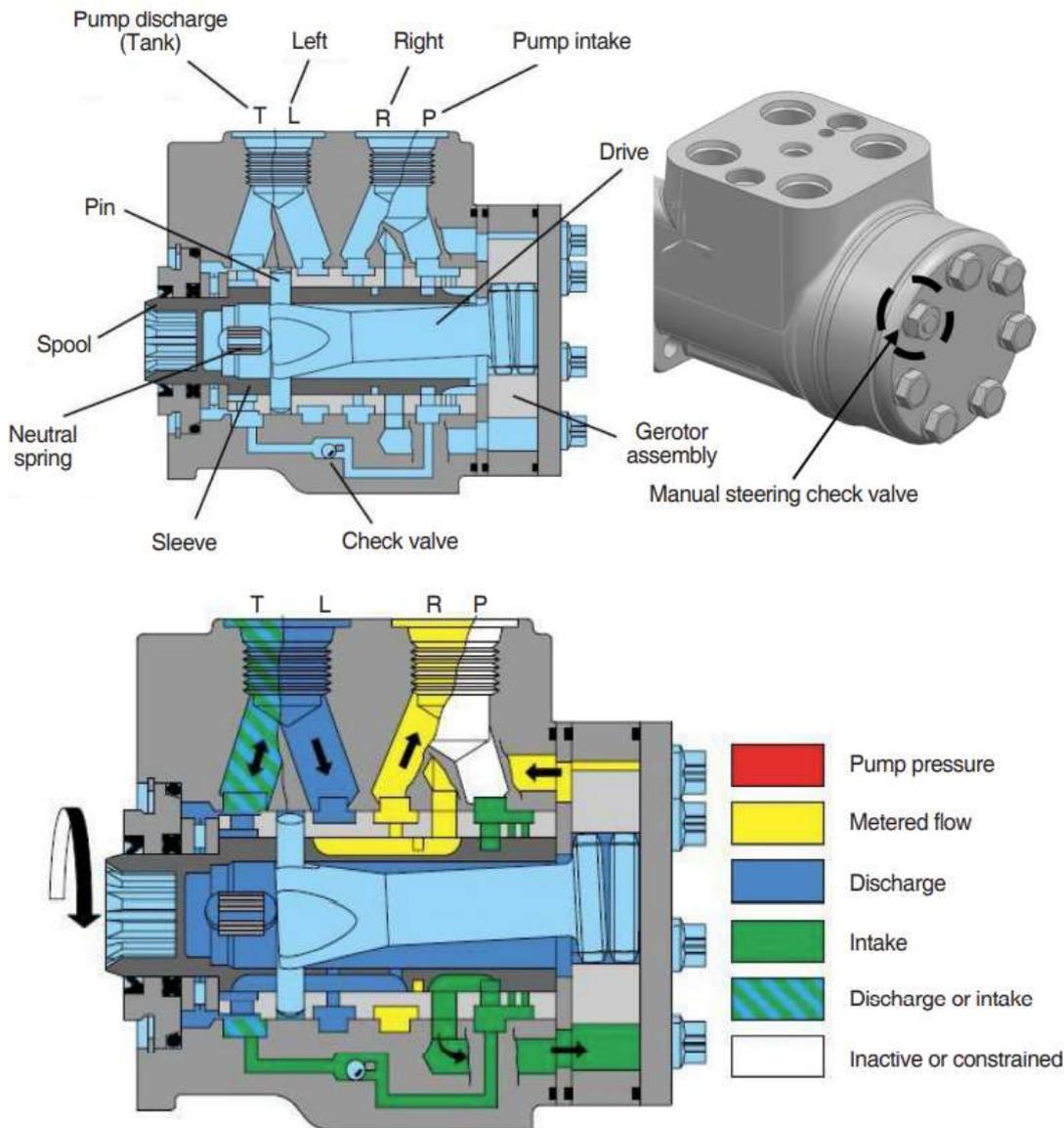
※ Seal kit: 5,7,9,22, 29

2) OPERATION

Steering unit is a closed neural circuit and a gauging gear set consisted of rotation valve (spool + sleeve set). Steering unit mitigates impact of sudden rotation or kickback of tire on steering wheel together with LS (load sensing) dynamic circuit to ensure smooth movement of steering wheel without interference when oil viscosity is low in winter season. LS circuit inside valve is used for control of operation of preferential valve spool.



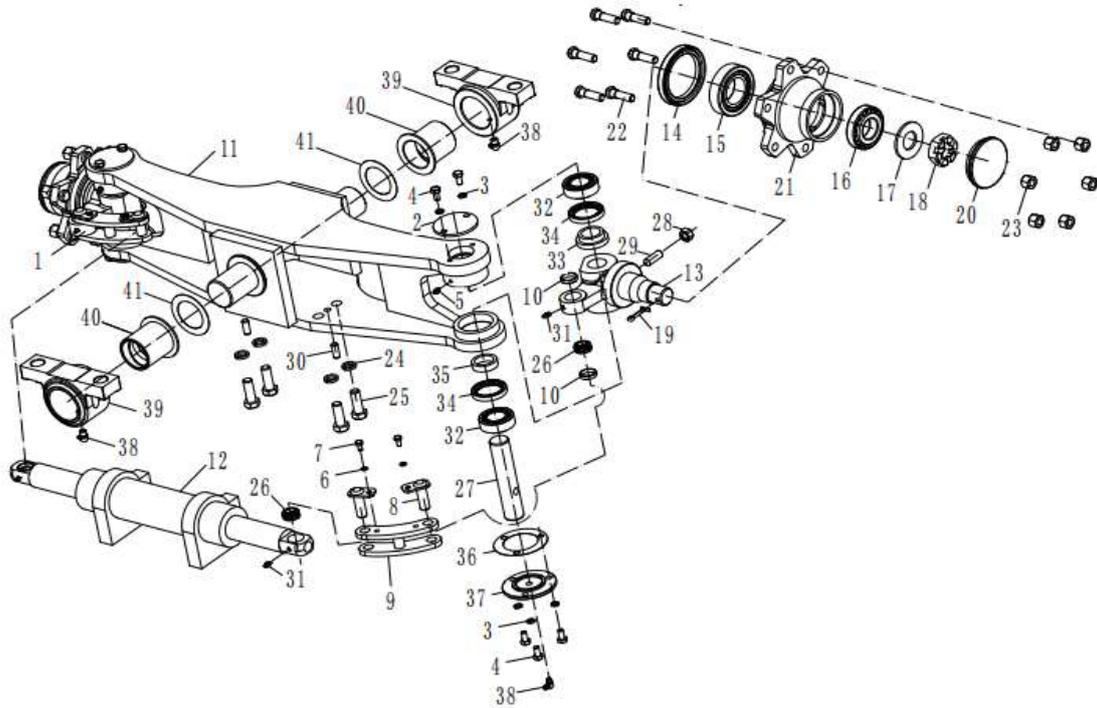
3) MANUAL STEERING IN EMERGENCY



Hydraulic motor stops, and preferential valve spool is pushed to the end by spring force when turning steering wheel. In such a case, hydraulic oil flows to spool and sleeve set, and EF port is closed. Turning steering wheel forms vacuum in supply line between preferential valve and steering unit spool and sleeve set. Path is opened for allowing flow of hydraulic oil to gerotor gear inside steering unit to rotate spool and sleeve set. Hydraulic oil entrapped in steering port flows through manual steering check valve, and is supplied to opposite steering cylinder through gerotor gear.

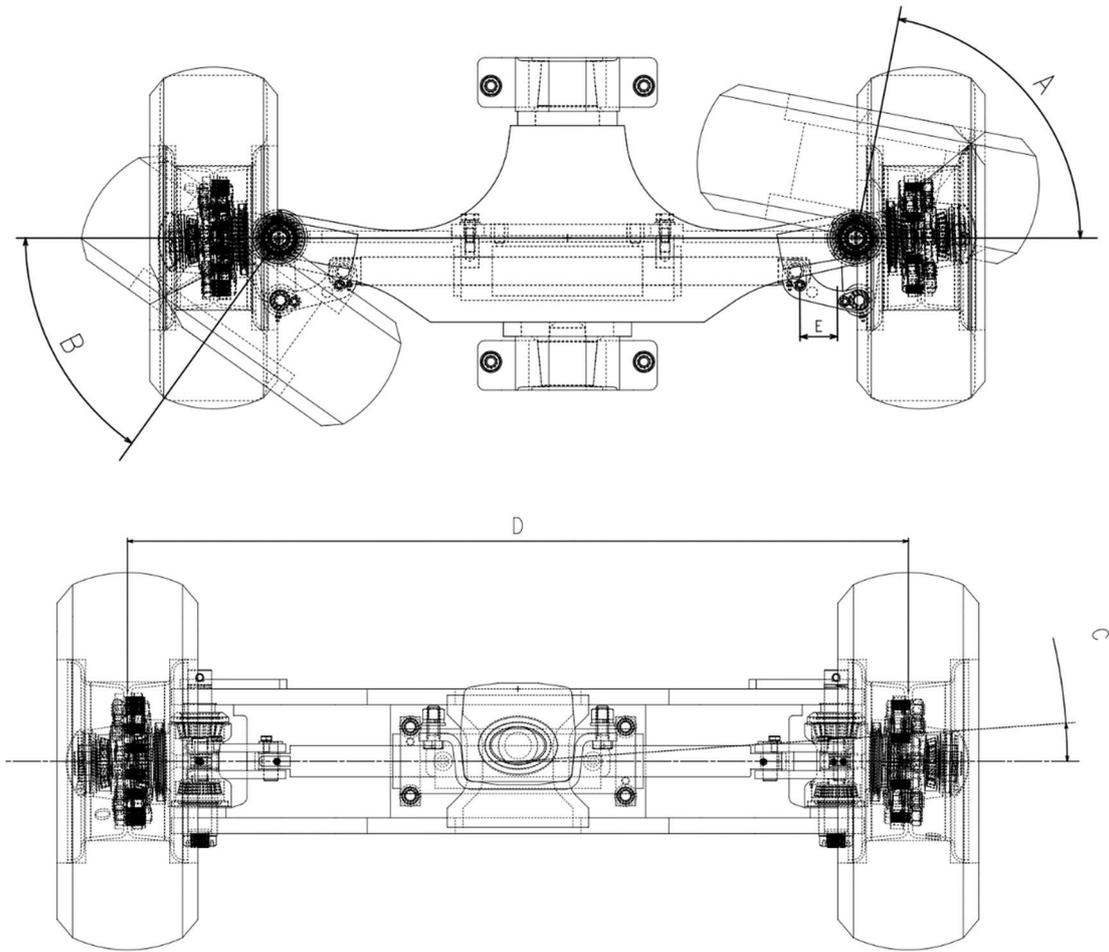
4. STEERING AXLE

1) Structure



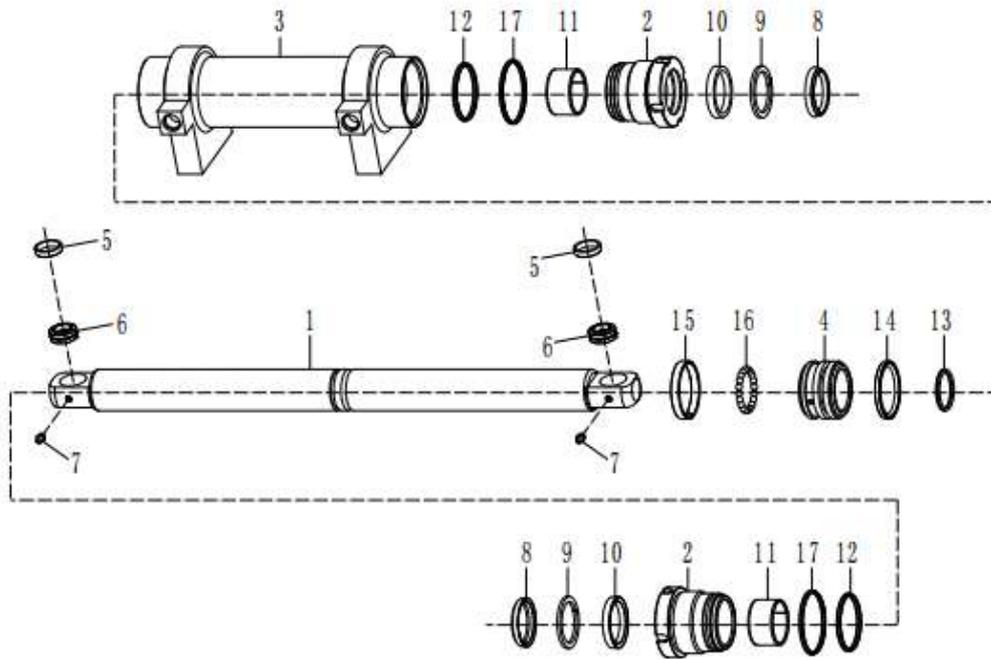
1	11	15	29
2	12	16	30
3	13	17	31
4	14	18	32
5	15	19	33
6	16	20	34
7	17	21	35
8	18	22	36
9	19	23	37
10	20	24	38
11	21	25	39
12	22	26	40
13	23	27	41
14	24	28	
15	25	29	
16	26	30	
17	27	31	
18	28	32	
19	29	33	
20	30	34	
21	31	35	
22	32	36	
23	33	37	
24	34	38	
25	35	39	
26	36	40	
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2) SPECIFICATION TABLE



Item			Unit	Specifications
Max. steering angle	Inner side	A	Degree	78.54
	Outer side	B		53.74
Reciprocating angle		C		1
Distance between wheels		D	mm	945
Stroke		E		72.5

5. STEERING CYLINDER



1	ROD	7	GREASE FITTING	13	O-RING
2	ROD COVER	8	DUST WIPER	14	GLEN CIRCLE
3	TUBE ASS'Y	9	RETAINING RING	15	RING
4	PISTON	10	SEAL	16	Steel Ball
5	CIRCLIP	11	DU-BUSH	17	O-RING
6	BEARING-SPH PLAIN	12	O-RING		

※ Seal kit: 5,8,9,10,12,13,14,15,17

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECK

Inspection items	Inspection procedures
Knuckle	<ul style="list-style-type: none"> · Inspect knuckle with visual checking, or crack inspection method. Bent knuckle indicates non-uniform abrasion of tires. Check abrasion of tires.
Steering axle	<ul style="list-style-type: none"> · Make request to assistant to drive the truck in the min. turning radius. · Affix chalk on outer edge of counterweight for drawing turning radius. · Min. turning radius (outside): see Section1 Group2 'specifications.'
Power steering pressure	<ul style="list-style-type: none"> · Install hydraulic pressure gauge on bidirectional pump. · Turn steering wheel as far as possible, and check hydraulic pressure. <p>Hydraulic pressure: 100 bar</p>

2. TROUBLESHOOTING

1) STEERING UNIT

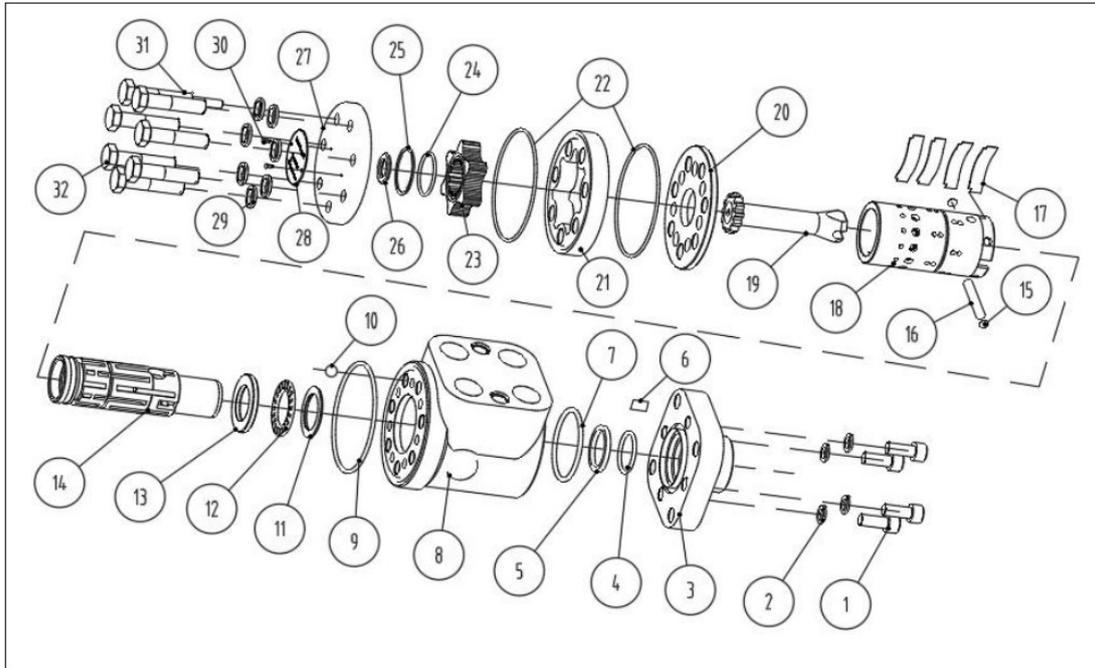
Trouble	Possible cause	Troubleshooting
Oil leak	· Bolts loose	· Tighten
	· Oil seal broken	· Replace
	· Washer broken	· Replace
Turn steering wheel need bigger force	· Pump supply insufficient oil	· Check oil pump and the oil hose connected to pump/repair or replace
	· Air in system	· Check/repair connection and exhaust air
	· Oil level in tank is lower than designed	· Add oil
	· Check valve (steel ball) disabled	· Clean the steel ball
	· The pressure is too low	· Check all system
Steering not allowed	· Spring broken	· Replace
	· Pin or shaft broken	· Replace
	· Incorrect installation in rotor and shaft	· Remount
	· Rotor or stator's gap is too big	· Replace

2) Steering axle

Trouble		Possible cause	Troubleshooting
Oil leak	Hub oil seal	· Broken	· Replace
	Cover-knuckle	· Broken	· Replace
	Knuckle oil seal	· Broken	· Replace
	Piston rod oily	· Dusty wiper broken · U-Packing broken · O-Ring broken · Piston rod surface is scratched	· Replace · Replace · Replace · Replace
	Cylinder body connector	· O-Ring broken	· Replace
Noise	Hub	· Hub bearing's gap is too big · Hub bearing broken	· Adjust · Replace
	King pin	· King pin bearing's gap is too big · Hub bearing broken · King pin is abrasive	· Adjust · Replace · Replace
	Pin-Steer link	· Bearing-SPH plain is abrasive · Pin-Steer link bearing is abrasive	· Replace · Replace
	Cylinder	· Connect bolts loosen · Ring-Back up broken · Steel ball position is abrasive · DU-Bush inner is abrasive	· Tighten · Replace · Replace · Replace

GROUP 3 DISASSEMBLY AND ASSEMBLY

1. STEERING UNIT

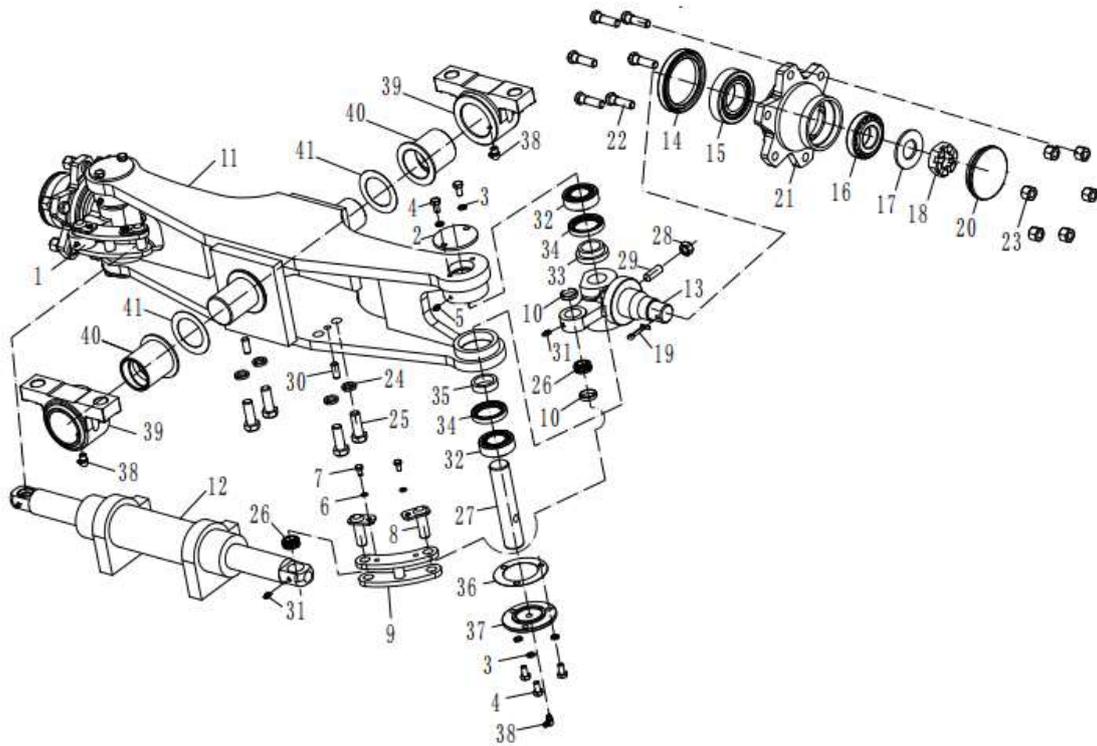


Disassemble

- 1) Remove bolt (32#) and rear cove (27#).
- 2) Remove sleeve-valve (18#) and shaft (19#) from body-valve (8#).
- 3) Remove O-Rings (9#/24#).
- 4) Remove bolts (1#) and front cover (3#).
- 5) Remove X-Ring (5#) and O-Ring (7#).

2. STEERING AXLE

Disassemble



- 1) Remove pin-steer link (8#) to remove links (9#).
 - 2) Remove bolt (25#) to remove steering cylinder (12#).
 - 3) Remove king pin (27#) to remove hubs (21#) and knuckles (1#/13#)
 - 4) Remove cap (20#) and nut (18#) to remove hub (21#) from knuckle (1#/13#).
- ※ Care should be exercised to protect O-ring and bearings.
 - ※ Store LH and RH knuckles respectively.

Assembling is the reverse order of removal and for more details please refer disassemble in next page.

Assemble

- 1) Mount outer ring of bearing (16#) into hub (21#) with a fixture.



- 2) Mount outer ring of bearing (15#) into hub (21#) with a fixture.



- 3) Mount bolt (22#) × 8 into hub (21#) with a fixture.



- 4) Apply lithium base grease on inside of hub (21#) until 1/3-1/2 of inside surface is applied.



5) Mount oil seal (14#) into hub (21#).



6) Mount bearing-SPH plain (26#) and bushing (10#)
× 2 into knuckle (1#/13#)



7) Mount the hub assy (21#) and knuckle (1#/13#)
together.



8) Mount inner ring of bearing (16#) into knuckle
(1#/13#).

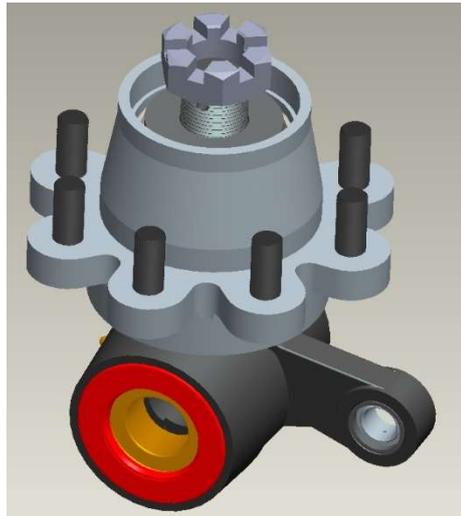


9) Mount washer (17#) into hub (21#).



10) Mount the nut-slotted (18#) into hub (21#). After tightening the nut with torque in 15 kgf·m, then return the nut 1/5 circle.

Check if the start torque of hub is 4.5-9 kgf·m. If not, adjust the nut-slotted (18#)



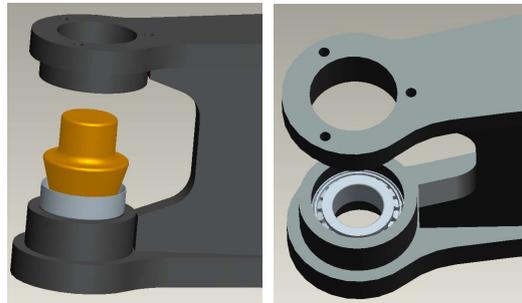
- 11) Mount the split pin (19#) into knuckle (1#/13#) after adjust the nut-slotted (18#).



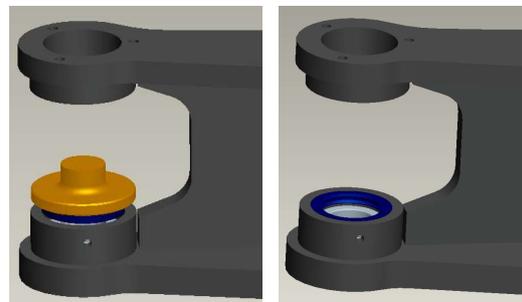
- 12) Mount the cap (20#) on hub (21#) with a rubber hammer.



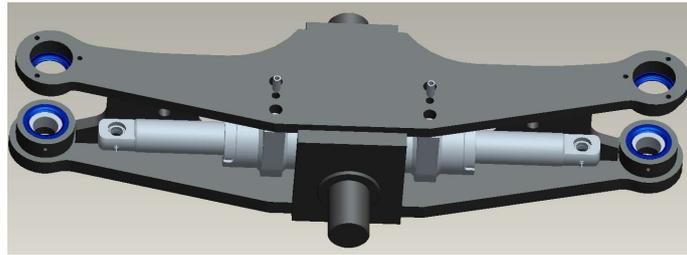
- 13) Mount the bearing (32#) × 2 into body (11#).



- 14) Mount seal (34#) into the bearing (32#) until the upper surface flush with the body (11#).

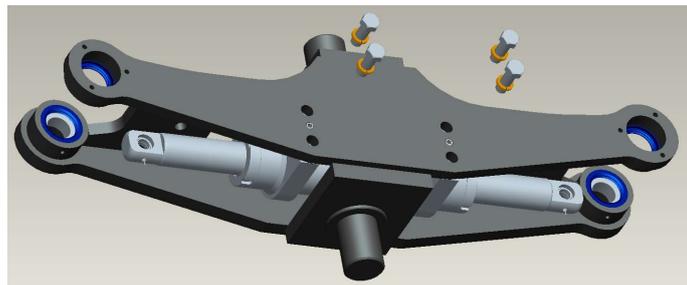


15) Mount the pin (30#) × 2 in body (11#).

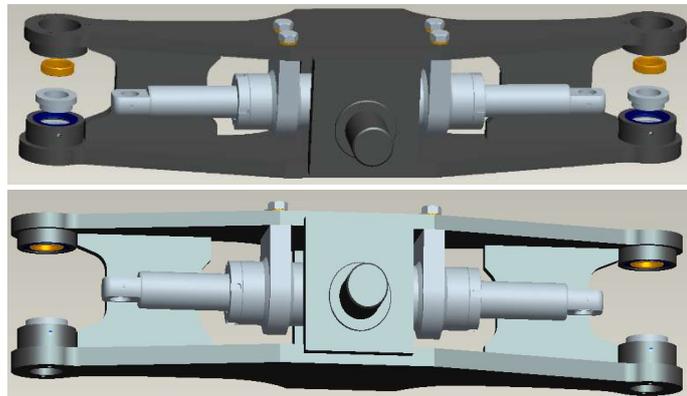


16) Mount washer-spring (24#) and bolt (25#) in body (11#).

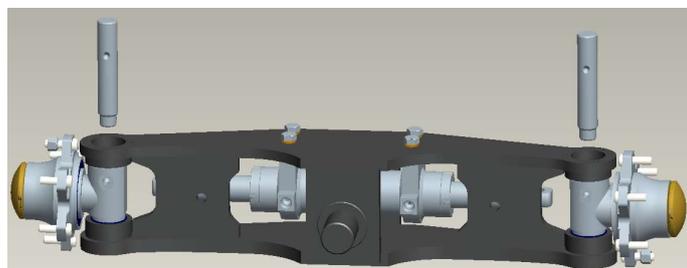
Fastening torque:11-13 kgf·m



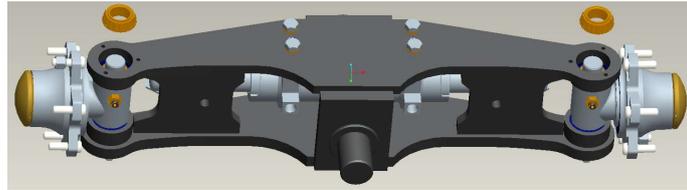
17) Mount the circlip (33#) × 2 and (35#) × 2 in the seal (34#).



18) Mount the knuckle (1#/13#) × 2 in body (11#) with king pin (27#) × 2.

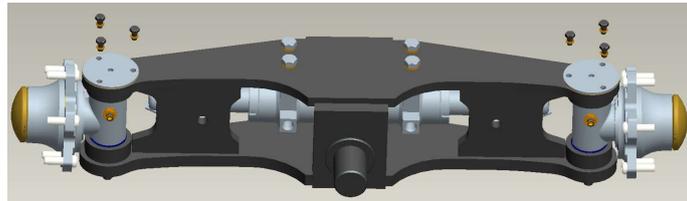
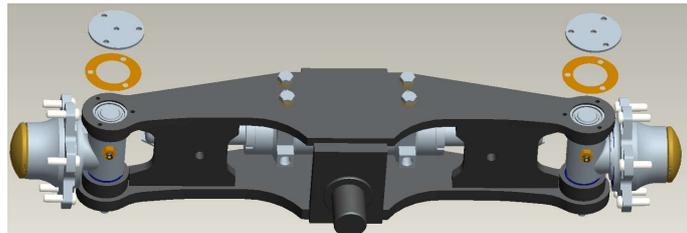


19) Mount the bearing (32#) × 2 between king pin (27#) and body (11#).



20) Mount the shim (36#) × 2 and plate (37#) × 2 with bolt (4#) × 6 and washer (3#) × 6 to body (11#).

Fastening torque: 2.5 kgf·m



21) Check if the start torque of rotating is 2.5-4.5 kgf·m.

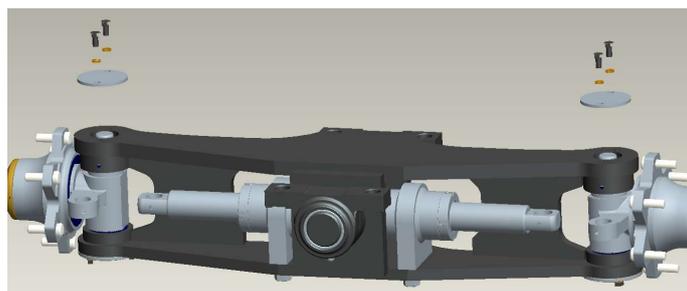
If it is greater than 4.5 kgf·m, add the number of shim (36#).

If it is less than 4.5 kgf·m, reduce the number of shim (36#).

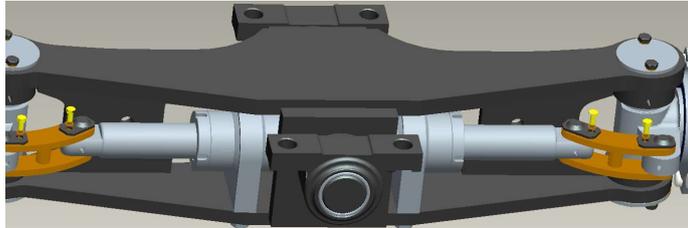


22) Mount the cover-king pin (2#) × 2 with bolt (4#) × 4 and washer (3#) × 4 to body (11#).

Fastening torque: 2.5 kgf·m



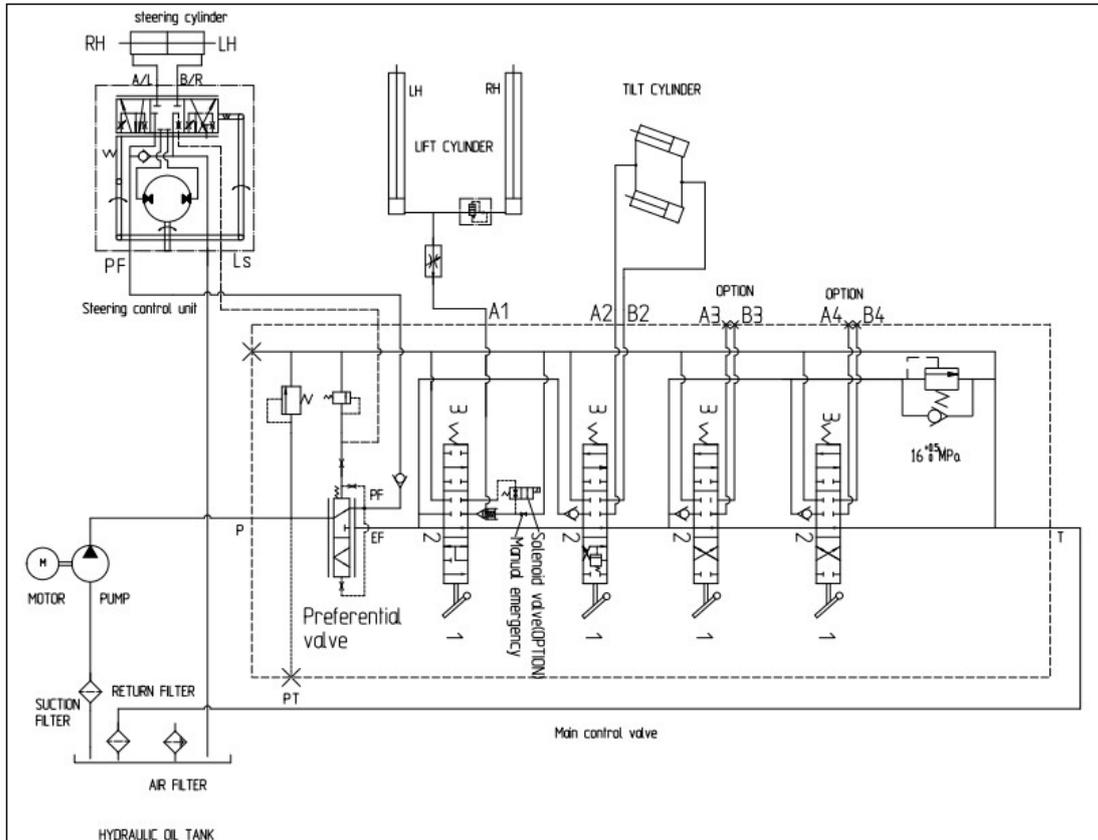
23) Mount link (9#) × 2 with pin-steer link (8#) × 4 to link knuckle (1#/13#) and steering CYL.Assy (12#).



SECTION 6 HYDRAULIC SYSTEM

GROUP 1 STRUCTURE AND FUNCTIONS

1. HYDRAULIC CIRCUIT



1) LIFT ASCENDING, TILTING REAR

When pulling lift and tilt operation lever, spools of first and second blocks move to position of lift ascending tilting backward. Hydraulic oil of hydraulic pump flows into main control valve to push rod check valve of spool to large chamber of lift cylinder and small chamber of tilt cylinder.

At the same time, hydraulic oil from small chamber of lift cylinder and large chamber of tilt cylinder returns to hydraulic oil tank. This hydraulic oil flow forms lift ascending and tile backward.

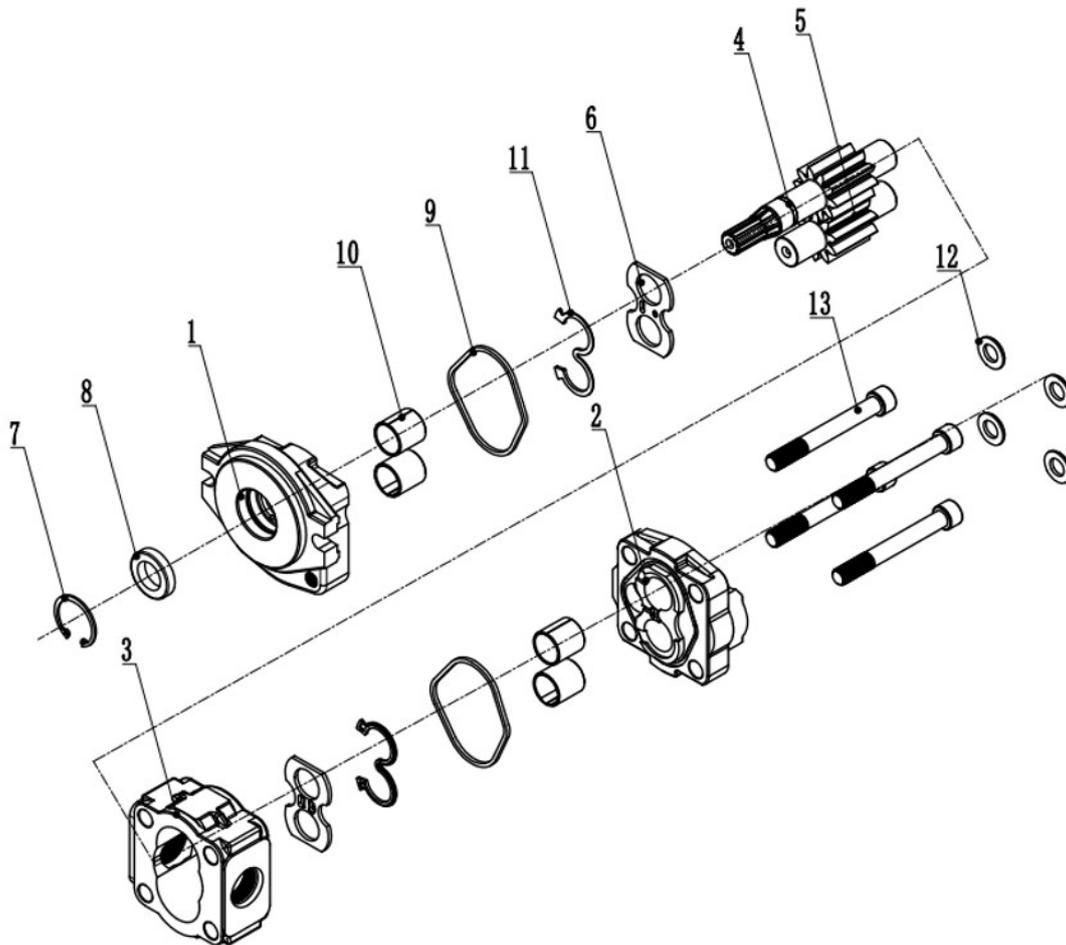
2) LIFT DESCENDING, TILTING FORWARD

When pushing lift and tilt operation lever, spools of first and second blocks move to position of lift descending tilting forward. Hydraulic oil of hydraulic pump flows into main control valve to push rod check valve of spool to move to large chamber of tilt cylinder.

Large and small chambers of lift cylinder are connected to return path to let return of hydraulic oil, and mast descends with weight of forks.

Hydraulic oil from small chamber of tilt cylinder is returned to hydraulic oil tank. This hydraulic oil flow forms tilting forward.

2. HYDRAULIC GEAR PUMP



1 Cover-Front

2 Cover-Rear

3 Body-Middle

4 Main Gear

5 Slave Gear

6 Plate

7 Ring-Retain

8 Oil Seal

9 Ring-Seal

10 Bush

11 3 Type Seal

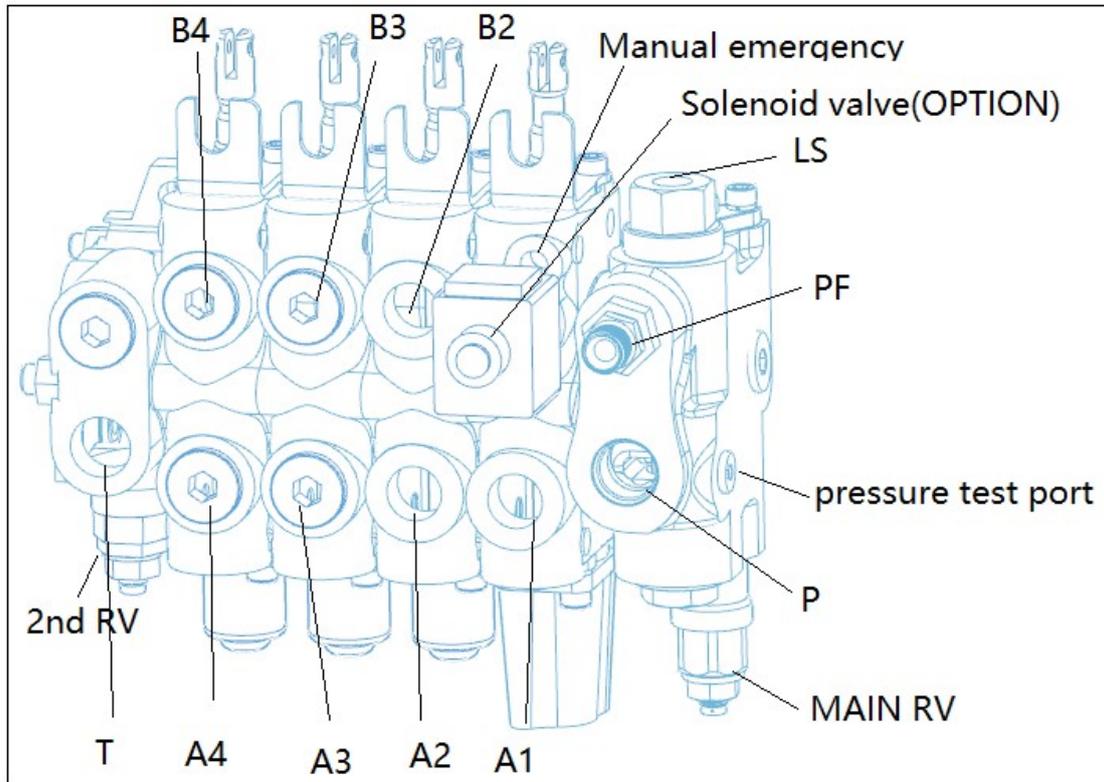
12 Washer

13 Bolt

※ Seal kit: 7,8,9,11

3. MAIN CONTROL VALVE

1) STRUCTURE

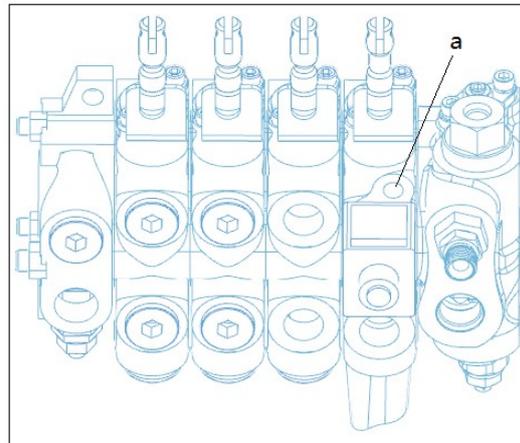


Port	Port name	Dimensions	Fastening torque
			kgf-m
A1	Lift	M20*1.5	5
A2, B2	Tilting	M20*1.5	5
A-, B-	Aux.	M20*1.5	5
P	Inlet	M22*1.5	7
T	Outlet	M22*1.5	7
PT	Gauge, pilot	PT1/8	1.5
PF	PF	M16*1.5	3
LS	LS	M12*1.5	1.5

2) FUNCTIONS

Emergency mast lowering.

In case that the mast can't be lowered due to a problem in the controller, activate the emergency lowering valve on the MCV assy by rotating the valve (a).



▲ Manual override features are intended for emergency use, not for continuous-duty operation.

① Loosen and remove the MCV cover connecting bolts.

Tightening torque :1.5 - 1.8 kgf-m

② Use the L-wrench (5 mm) to loosen the bolts counterclockwise until lowering of the mast begins.

※ Do not undo the bolts more than 1.5 turns.

※ If lowering still does not begin, there is a mechanical block. Do not under any circumstances continue to unscrew the emergency lowering feature.

③ After lowering is complete, the valve must be screwed back in again.

※ Do not exceed a tightening torque of maximum 1.8 kgf-m.

▲ When operating the emergency lowering valve in order to lower the mast inevitably, always make certain that any person should not stand or pass under the mast, the fork and platform so as to avoid from unexpected accident such severe personal injury or death.



Cutoff solenoid for blocking hydraulic pressure

This equipment is a mast interlock that preventing activation of hydraulic functions of main control valve until operator sits on the seat. The system is also a key-lowering interlock system that prevents fork descending while start key is kept on OFF position. This safety function is defined in ISO 3691-1, and should not discretionally be deactivated on main control valve.

Relief valve

① Primary relief valve (DV1)

Primary relief valve limits max. pressure of lifting and tilting function. When lifting or tilting function operates simultaneously with aux. function, max. pressure of lifting or tilting function is limited by pressure setup of secondary relief valve. Primary relief valve does, typically, not require field adjustment. Refer to testing and adjustment of relief valve for further information of adjustment.

② Secondary relief valve (DV2)

Secondary relief valve limits max. pressure of aux. (attachment) function, and pressure setting of the valve is lower than primary relief valve. Secondary relief valve may require pressure adjustment dependent upon types of attachments. If it is required to adjust pressure, adjustment within 90% of primary relief valve pressure is recommended (e.g., $200 \times 0.9=180$ bar). If pressure of secondary relief valve is too close to pressure of primary relief valve, interference

between circuits may take place. Refer to testing and adjustment of relief valve for further information of adjustment. Up to 2 optional functions are provided.

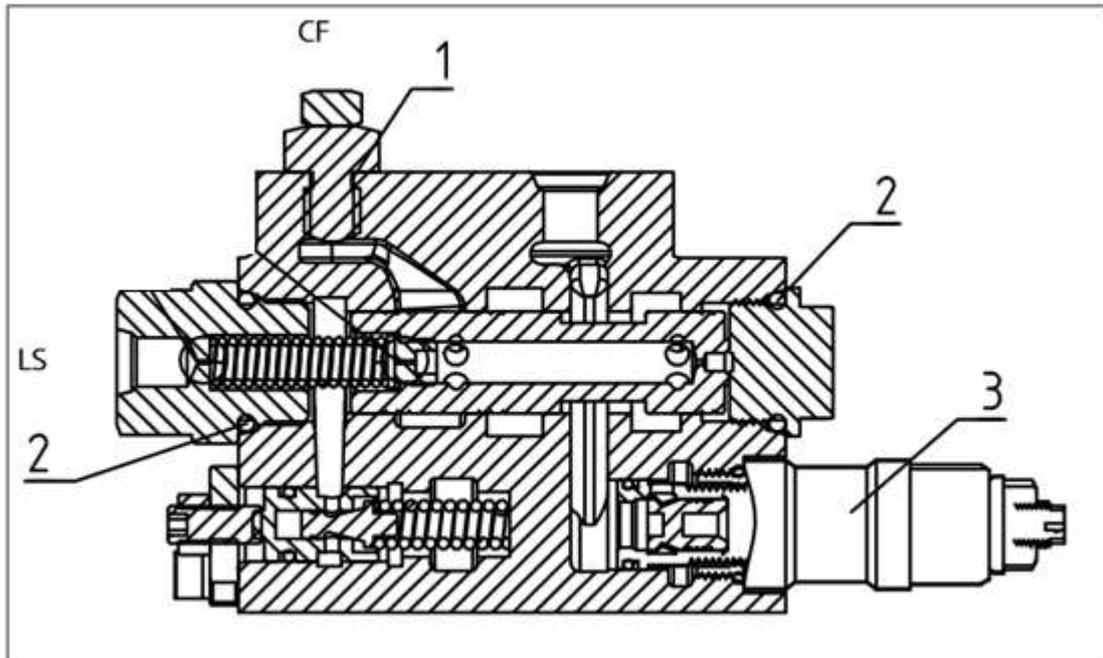
3) RELIEF VALVE PRESSURE TESTING AND ADJUSTMENT

Test specifications

- Hydraulic motor speed: High rpm
- Oil temperature: $50 \pm 5^{\circ}\text{C}$ ($122 \pm 9^{\circ}\text{F}$)
- Relief valve pressure setting
 - Primary : $195 \pm 5\text{bar}$
 - Secondary : $160 \pm 5\text{ bar}$
- Tools : lock nut 17mm, internal hex 5mm

- ▲ Primary relief valve (DV1) should not be used for pressure boosting at field. When boosting pressure of primary relief valve higher than specified setting, system may be damaged.
- ▲ Check relief valves in safe and clean environment.
- ▲ Make sure there is no bystanders or other workers in the vicinity of system during operation and testing.
- ▲ Pressurized hydraulic oil may remain in hydraulic system after turning off. Fully lower forks onto the ground to prevent personal safety accident. Loosened mast chain indicates fully lowering of forks.
- ▲ Turn engine off before disassembling, fastening, removing or adjusting piping parts (e.g., fitting, plug and hose), and fully move main control valve lever forward and backward two or three times to fully discharge hydraulic oil from circuits. Open tank oiling cap to relieve pressure. When air breather filter inside hydraulic oil tank is clogged, pressure may reside inside tank.
- ▲ Hot hydraulic oil may cause severe burn. Never touch components or hydraulic oil during testing. Make sure that hydraulic oil is cooled down to safe temperature before installing or removing testing systems.
- ▲ Your skin may contact with pressurized hydraulic oil. Fully lower forks onto the ground before removing test plug from valve, and then relieve pressure from all of circuits.
 - ① Operate hydraulic system until oil temperature reaches specified value in test specifications.
 - ② Lower forks onto the ground, stop engine, and then apply parking brake.
 - ③ Open cover of main control valve.
 - ④ Connect pressure gauge to pressure check port (G) of main control valve.
 - ⑤ Operate pump motor in accordance with test specifications.
 - ⑥ Pull lift lever to raise forks to the top, and keep the conditions as they are.
 - ⑦ Read pressure gauge. Compare value on the gauge with specifications.
 - ⑧ Loosen lock nuts of main control valve and relief valve, and turn adjustment screw to adjust pressure.
 - Fastening torque : $3.8\text{ kgf}\cdot\text{m}$
 - If pressure is lower than specification, turn relief valve adjustment screw clockwise.
 - If pressure is higher than specifications, turn relief valve counterclockwise.
- ▲ Adjustment screw of MCV relief valve is very sensitive. Rotate the screw by a quarter turn to prevent overpressure.
- ⑨ Repeat Steps 7 and 8. When pressure is compliant with the specifications, remove testing equipment.

4) PREFERENTIAL VALVE



1 O-Ring

2 O-Ring

3 Main Relief Valve

The priority valve is integrated into the main valve. The valve is affected by the LS signal on the steering device to ensure that sufficient oil is supplied to the steering circuit. The valve maintains a constant steering force and speed to resist changes in the pump hydraulic oil supply flow, and first supplies hydraulic oil to the steering circuit.

4. LIFT CYLINDER

1) V MAST

⑧	AS568 014	O-RING 12.42x1.78	1	NBR		NOK
⑦	AS568 116	O-RING 18x2.65	1	NBR		NOK
⑥	OSI 45x35x6	U-PACKING	1	PU		NOK
⑤	∅45x∅35x3	RING-BACKUP	1	PIPE		
④	D45x15x2.5	RING-WEAR	1	PF		
③	AS568 133	O-RING 45x2.65	1	NBR		NOK
②	ISI 35x45x6	U-PACKING	1	PU		NOK
①	LBI 35x43x5/6.5	WIPER-SNAP	1	PU		NOK
37MD16V55x35-MFB密封包明细						
12	H11020-SV100	SHUT-OFF VALVE/PL/Min	1	ASSEMBLY		※One of 2 Cyl.
11	TLC-15T24	VALVE-SLEEVE	1	20		
10	TLC-15T23	SPACER	1	45		
9	GB895.1-86	STOP RING d0=24	2	65Mn		
8	TLC015-SV100	CHECK VALVE	1	ASSEMBLY		
7	TLC-15T22A	PISTON	1	45		
6	LIFT-GT35x43xK	SPACER	1	45		
5	SEE TABLE	PIPE	1	WELD		
4	SEE TABLE	ROD	1	45		
3	GB982-77	GASKET 6	1	COMPOSITE		
2	GB70.2-85	SCREW M6x5	1	8.8GRADE		
1	37MD16V55x35-1	GLAND	1	QT450-10		
NO.	PART NO.	PART NAME	Q'TY	MATERIAL	WEIGHT	REMARK
序号	代号	名称	数量	材料	重量	备注

2) TF MAST

⑧	AS568 014	O-RING 12.42x1.78	1	NBR		NOK
⑦	AS568 116	O-RING 18x2.65	1	NBR		NOK
⑥	OSI 45x35x6	U-PACKING	1	PU		NOK
⑤	∅45x∅35x3	RING-BACKUP	1	PIPE		
④	D45x15x2.5	RING-WEAR	1	PF		
③	AS568 133	O-RING 45x2.65	1	NBR		NOK
②	ISI 35x45x6	U-PACKING	1	PU		NOK
①	LBI 35x43x5/6.5	WIPER-SNAP	1	PU		NOK
37MD16TF55x35-MFB密封包明细						
12	H11020-SV100	SHUT-OFF VALVE/PL/Min	1	ASSEMBLY		※One of 2 Cyl.
11	TLC-15T24	VALVE-SLEEVE	1	20		
10	TLC-15T23	SPACER	1	45		
9	GB895.1-86	STOP RING d0=24	2	65Mn		
8	TLC015-SV100	CHECK VALVE	1	ASSEMBLY		
7	TLC-15T22A	PISTON	1	45		
6	LIFT-GT35x43xK	SPACER	1	45		
5	SEE TABLE	PIPE	1	WELD		
4	SEE TABLE	ROD	1	45		
3	GB982-77	GASKET 6	1	COMPOSITE		
2	GB70.2-85	SCREW M6x5	1	8.8GRADE		
1	37MD16TF55x35-1	GLAND	1	QT450-10		
NO.	PART NO.	PART NAME	Q'TY	MATERIAL	WEIGHT	REMARK
序号	代号	名称	数量	材料	重量	备注

3) TF FREE MAST

⑦	D65x20x2.5	RING-WEAR	1	PF		
⑧	PH4200650-Z13N	SEAL-PISTON 65x54x4.2	1	COMBINATION SEAL		TSS
⑥	G60	O-RING #65x3.1	1	NBR		NOK
④	G65	O-RING #70x3.1	1	NBR		NOK
③	ISI 45x55x6	U-PACKING	1	PU		NOK
②	D55x44x3	RING-BACKUP	1	PIPE		
①	LBI 45x53x5/6.5	WIPER-SNAP	1	PU		NOK
37MD16TF76x45-MFB密封包明细						
13	GB119-86	PIN A10x25	1	35		
12	HHI025-SV100	SEMI-OFF VALVE 90L/Min	1	ASSEMBLY		
11	GB893.1-86	RETAINING RING D22	1	65Mn		
10	TLC030-SV100	CHECK VALVE	1	ASSEMBLY		
9	TLC-30T39	STOP RING	1	65Mn		
8	37MD16TF76x45-3	PISTON	1	45		
7	TLC-30T37	PIPE	1	20		
6	SEE TABLE	ROD	1	45		
5	SEE TABLE	TUBE ASS'Y	1	WELD		
4	GB982-77	GASKET 6	1	COMPOSITE		
3	GB70.2-85	SCREW M6x5	1	8.8GRADE		
2	37MD16TF76x45-1	GLAND	1	45		
1	SF-1/45x50x45	DU BUSH	1	COMPOSITE		
NO.	PART NO.	PART NAME	Q'TY	MATERIAL	WEIGHT	REMARK
序号	代号	名称	数量	材料	重量	备注

5. TILT CYLINDER

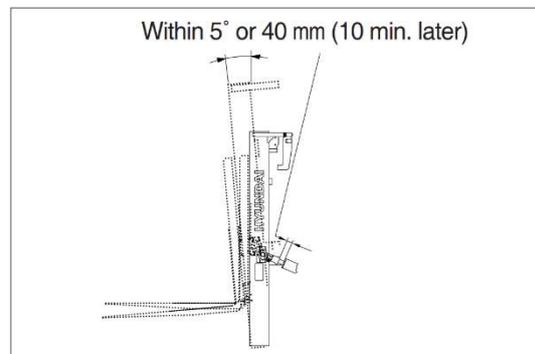
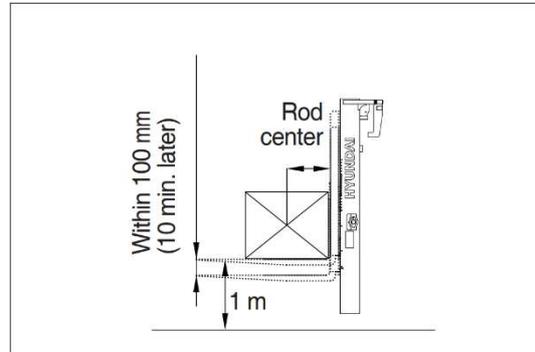
⑨	D70x16x2.5	RING-WEAR	1	PF		
⑧	PH4300700-Z13N	SEAL-PISTON 70x54.6x4.3	1	COMBINATION SEAL		TSS
⑦	P32	O-RING 38x3.5	1	NBR		NOK
⑥	AS668 011	O-RING 7.65x1.78	2	NBR		NOK
⑤	AS668 230	O-RING 70x3.5	1	NBR		NOK
④	AS668 149	O-RING 71x2.65	1	NBR		NOK
③	ISI 32x42x6	U-PACKING	1	PU		NOK
②	842x832x3	RING-BACKUP	1	PIPE		
①	LBI 32x40x5/6.5	WIPER-SNAP	1	PU		NOK
37MD15V82x32-MFB密封包明细						
12	GB6171-88	NUT-HEXAGON M24x2	1	8GRADE		
11	37MD15V82x32-3	PISTON	1	45		
10	37MD15V82x32-100W1	TUBE ASS'Y	1	WELD		
9	37MD15V82x32-2	ROD	1	42CrMo		
8	SF-1/832x896x36	DU BUSH	1	COMPOSITE		
7	37MD15V82x32-1	GLAND	1	45		
6	GB/T 6170-2000	NUT-HEXAGON M12	1	10GRADE		
5	GB/T 93-87	WASHER-SPRING 14	1	65Mn		
4	GB/T 5782-2000	BOLT-HEXAGON M12x80	1	10.9GRADE		
3	3YEH30V87x35-1	EYE-ROD	1	45FORGE		
2	GE36ES-F-01	BEARING-SPHERICAL	1	GCr15		
1	GB1162-79	NIPPLE-GREASE M10x1	1	ASSEMBLY		
NO.	PART NO.	PART NAME	Q'TY	MATERIAL	WEIGHT	REMARK
序号	代号	名称	数量	材料	重量	备注

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

1. OPERATIONAL CHECK

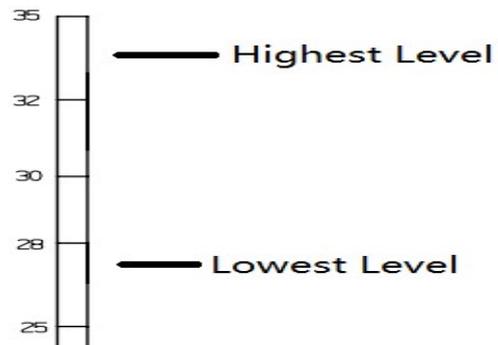
1) INSPECTION ITEMS

- ① Visually check rod for deformation, crack or destruction.
- ② Place mast in horizontal direction, and lift it from the ground by 1 m. Measure hydraulic drift (distance for fork lowering, and mast tilting forward) 10 minutes later.
 - Inspection conditions
 - Hydraulic oil temperature: $45 \pm 5^{\circ}\text{C}$
 - Rated load
 - Mast kept vertical
 - Hydraulic drift
 - Lowering: Within 100 mm
 - Tilting forward: Within 5° or 40 mm
- ③ If hydraulic drift is greater than specified value, replace control valve or cylinder packing.



2) HYDRAULIC OIL

- ① Make use of dipstick to measure oil level, and make it up, if required.
- ② Clean suction strainer fixed on outlet port pipe with screw when exchanging hydraulic oil.



3) MAIN CONTROL VALVE

Raise forks to the highest position, and measure hydraulic pressure. Make sure that pressure of hydraulic oil is 210 bar.

2. FAILURE DIAGNOSIS AND TROUBLESHOOTING

1) HYDRAULIC SYSTEM

Trouble	Possible cause	Troubleshooting
Sudden drop of forks	<ul style="list-style-type: none"> · Defective seal inside control valve · Oil leak from joint or hose. · Defective seal inside cylinder. 	<ul style="list-style-type: none"> · Replacing spool or valve body. · Replacing · Packing exchange.
Large tilting angle by tare weight of mast	<ul style="list-style-type: none"> · Leaning backward: Defective check valve. · Leaning forward: Defective tilting lock valve. · Oil leak from joint or hose. · Defective seal inside cylinder. 	<ul style="list-style-type: none"> · Cleaning or replacing. · Cleaning or replacing. · Replacing. · Seal replacing.
Slow speed of fork lifting or mast tilting	<ul style="list-style-type: none"> · Insufficient hydraulic oil. · Intrusion of air in hydraulic oil. · Oil leak from joint or hose. · Excessive restriction on oil flow on pump suction. · Relief valve failed in keeping at specified pressure. · Defective seal inside cylinder. · High viscosity of hydraulic oil · Mast not moving smoothly. · Oil leak on lift control valve spool. · Oil leak on tilting control valve spool. 	<ul style="list-style-type: none"> · Oil making up. · Air bleeding · Replacing. · Filter cleaning. · Relief valve adjusting. · Packing exchange. · Replacing with ISO VG46. · Adjusting rolls in rail interval · Replacing spool or valve body. · Replacing spool or valve body.
Abnormal noise from hydraulic system	<ul style="list-style-type: none"> · Excessive restriction on oil flow on pump suction. · Defective hydraulic pump gear or bearing. 	<ul style="list-style-type: none"> · Filter cleaning. · Gear or bearing replacing.
Control valve lever locked	<ul style="list-style-type: none"> · Foreign substance between spool and valve body. · Defective valve body. 	<ul style="list-style-type: none"> · Cleaning. · Evenly tightening body mounting bolt.
Rise of oil temperature	<ul style="list-style-type: none"> · Insufficient hydraulic oil. · High viscosity of hydraulic oil. · Oil filter clogged. 	<ul style="list-style-type: none"> · Oil making up. · Replacing with ISO VG46. · Filter cleaning.

2) HYDRAULIC GEAR PUMP

Trouble	Possible cause	Troubleshooting
Oil leak from oil seal	<ul style="list-style-type: none"> · Backlashing · Abnormally high pressure on suction port · Seal damaged by foreign substance · Damage or abrasion of seal of shaft · Defective centering of shaft 	<ul style="list-style-type: none"> · Rotating pump in correct direction · Keeping pressure proper · Replacing oil seal with new part · Centering adjustment. · Pump replacing.
Oil leak on cover or body interface	<ul style="list-style-type: none"> · Bolt loosened or damaged on cover and body · Deterioration or damage of oil seal by thermosetting of gasket 	<ul style="list-style-type: none"> · Bolt fastening or keeping pressure proper. · Replacing gasket with new part
Oil leak on port	<ul style="list-style-type: none"> · Port fitting damaged or loosened · Port seal damaged · Port damaged 	<ul style="list-style-type: none"> · Port tightening and keeping design pressure intact · Port seal replacing · Pump replacing
Discharge flow insufficient, or pressure not established	<ul style="list-style-type: none"> · Insufficient oil in tank · Internal oil leak by abnormally high pressure, or improper oil viscosity · Capability degraded by oil contamination · Cavitation by negative pressure · Internal part destructed · Backlashing 	<ul style="list-style-type: none"> · Suppling oil of proper type and capacity into tank, and cooling system replacing. · Exchanging contaminated oil. · Using suction pipe of proper length and width, and replacing filter to prevent negative pressure. · Suction valve opening · Pump replacing · Rotating pump in correct direction, and preventing abnormally high temperature on suction side.
Rise of tank or oil temperature	<ul style="list-style-type: none"> · Abnormal heat generated by frequent operation of pressure control valve · Internal part destructed 	<ul style="list-style-type: none"> · Setting to proper pressure. · Pump replacing.
Noise and vibration	<ul style="list-style-type: none"> · Poor mounting · Cavitation · Air induced · Vibration of piping or mounted flange · Chattering of relief valve · Internal part destructed 	<ul style="list-style-type: none"> · Centering adjustment · Using suction pipe of proper length and width, and replacing filter to prevent negative pressure. · Filling tank with oil, and preventing air inducing with suction pipe. · Reinforcing pipe and mounting flange, and preventing resonance. · Replacing relieve valve. · Pump replacing.

※ Capability of disassembled pump may not be restored after reassembling.

※ If pump is destructed, replace the assembly.

※ If it is inevitable to disassemble pump, consult with the authorized shop or dealer of HD HYUNDAI.

3) LIFT CYLINDER

Trouble	Possible cause	Troubleshooting
Oil leak on rod cover through rod	<ul style="list-style-type: none"> · Foreign substance on packing. · Severe flaw on rod. · Abnormal distortion of dust seal. · Chromium plating damaged 	<ul style="list-style-type: none"> · Packing replacing. · Grinding rod surface with oil stone. · Dust seal replacing. · Rod replacing.
Oil leak on cylinder rod cover thread	<ul style="list-style-type: none"> · O-ring damaged. 	<ul style="list-style-type: none"> · O-ring replacing.
Rod shrunken	<ul style="list-style-type: none"> · Flaw on internal surface of tube. · Very serious flaw on internal surface of tube. · Foreign substance into piston seal. 	<ul style="list-style-type: none"> · Grinding rod surface with oil stone. · Cylinder tube replacing. · Piston seal replacing.
Abrasion (play between cylinder tube and abrasion ring)	<ul style="list-style-type: none"> · Serious play between cylinder tube and abrasion ring. 	<ul style="list-style-type: none"> · Abrasion ring replacing.
Abnormal noise when tilting operation	<ul style="list-style-type: none"> · Insufficient lubricant on anchor pin or bushing or pin abraded. · Tilt cylinder rod bent. 	<ul style="list-style-type: none"> · Applying lubricant or replacing. · Replacing.

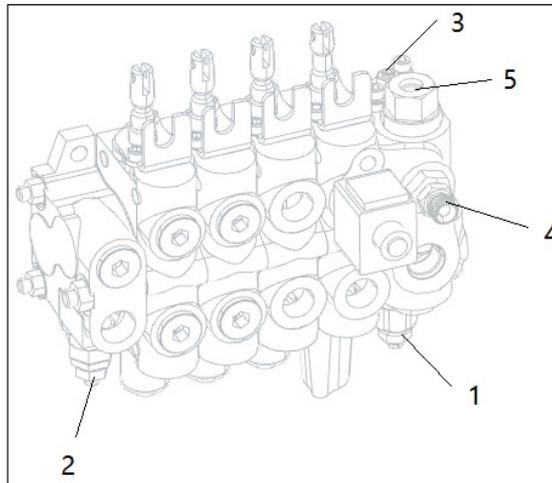
GROUP 3 DISASSEMBLY AND ASSEMBLY

Always work in clean environment, and comply with the followings:

- Make sure that there is no damage of parts immediately after accepting them.
- All of components should be cleaned with solvent, and dried with compressed air before reassembling.
- Care should be exercised for protecting rubber seal from damage.
- Care should be exercised for protecting precise-machined surface from damage.
- Components should be inserted into housing not exercising large force. If large force is required, dimensional tolerances of parts are not complied with or misaligned.
- If force of hands is not sufficient, use press or rubber mallet.
- Never strike part with iron hammer.
- Proper press should be used for metal bushing.
- Do not use mallet for mounting bearings.
- Always pay attention to rotation direction when assembling parts.

1. MAIN CONTROL VALVE

1) STRUCTURE



1 Main relief valve

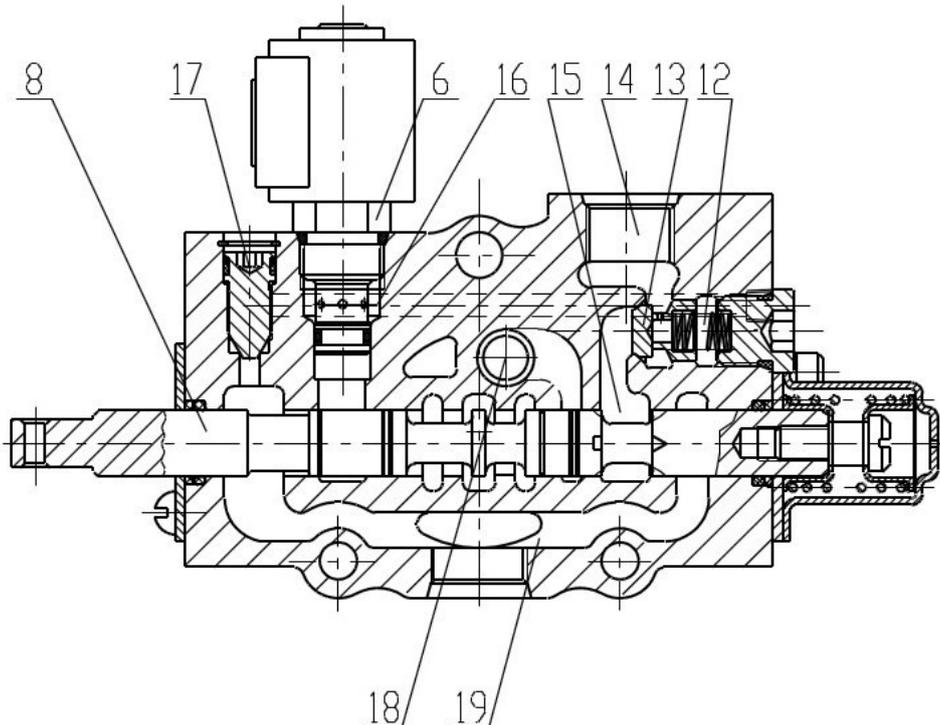
2 2 nd relief valve

3 Steering relief valve

4 To steering unit P port

5 To steering unit LS port

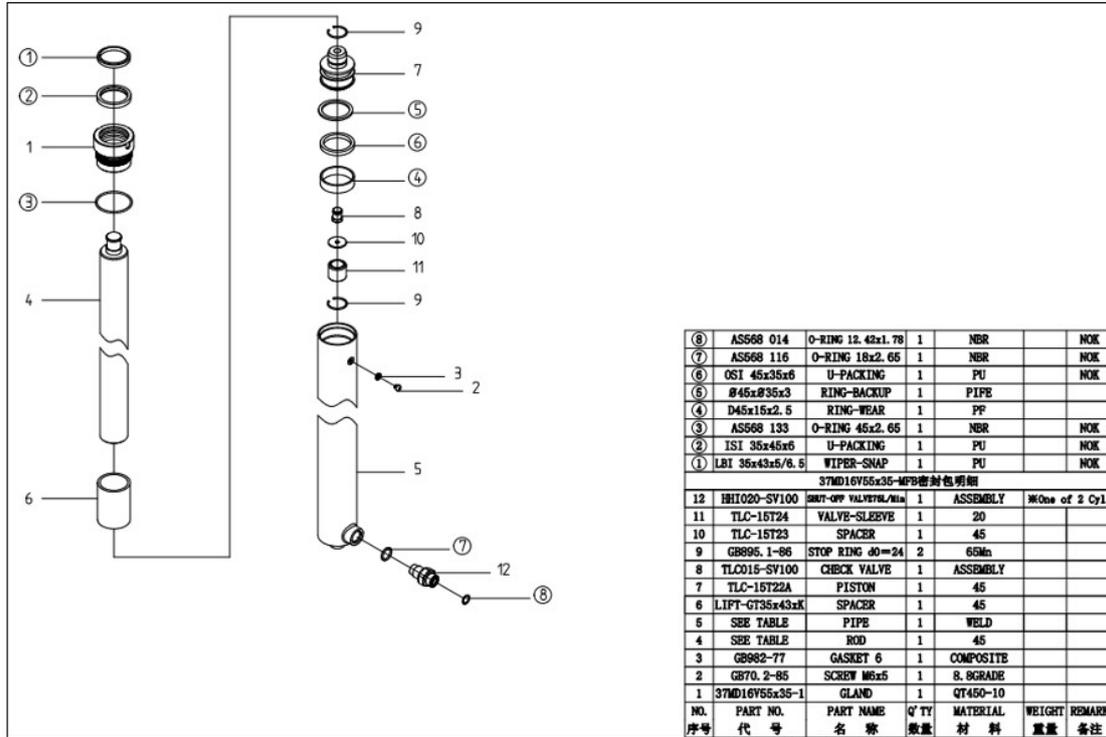
2) DISASSEMBLING AND ASSEMBLING



- ① Hydraulic oil model: N32 hydraulic oil
- ② During handling, installation and storage, avoid collision and damage to the processing oil port.
- ③ It is not allowed to disassemble and assemble in dusty places before installation to prevent dirt from entering.
- ④ Before use, check whether the rated pressure, spool valve function, oil circuit type and function meet the system requirements.
- ⑤ The mounting plate and bracket shall be flat, and the tightening force of the mounting screws shall be uniform, and the valve shall not be twisted.
- ⑥ The working fluid should be clean, and the cleanliness of the fluid should reach NAS 1638 level 10 or above.
- ⑦ Allowable oil temperature: - 20 °C~80 °C.
- ⑧ Connect the oil ports correctly, and the pipeline should not be too thin or too long.
- ⑨ On the premise that the user complies with the rules of storage, use, installation and transportation, the factory implements "three guarantees" in case of failure due to manufacturing quality problems within one year from the date of delivery.

2. LIFT CYLINDER

1) STRUCTURE

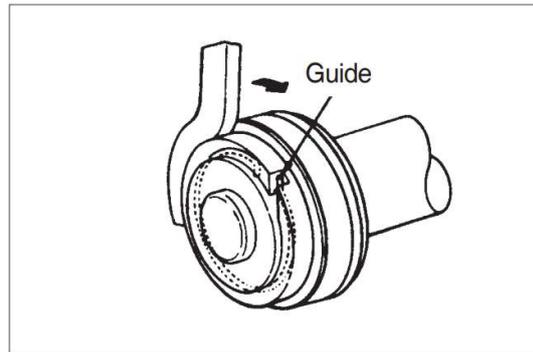


Inner diameter	Outer diameter	Stroke	Rod (outer diameter)
45 mm	55 mm	1495 mm	35 mm

2) DISASSEMBLING

Hold cylinder tube in vice, and loosen and remove cylinder head.

Remove space from cylinder tube, and pull bushing out. Connect wrench to the hole of retainer at the end of piston, and turn the wrench. Lift the edge of guide and turn guide to move guide.



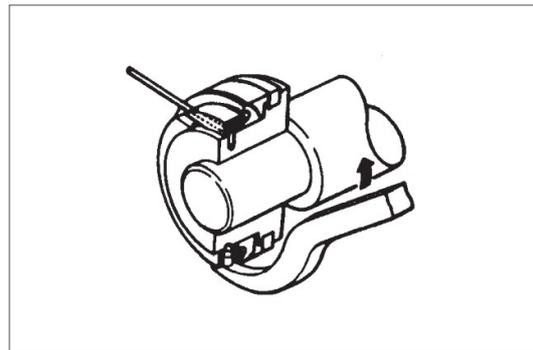
3) CHECKING AND INSPECTION

Inspection items	Standard dimensions	Limit on repair	Troubleshooting
Gap between cylinder rod and bushing	0.072 - 0.288mm	0.5mm	Bushing Replacing
Gap between piston ring and tube	0.05 - 0.030mm	0.5mm	Piston ring Replacing

4) ASSEMBLING

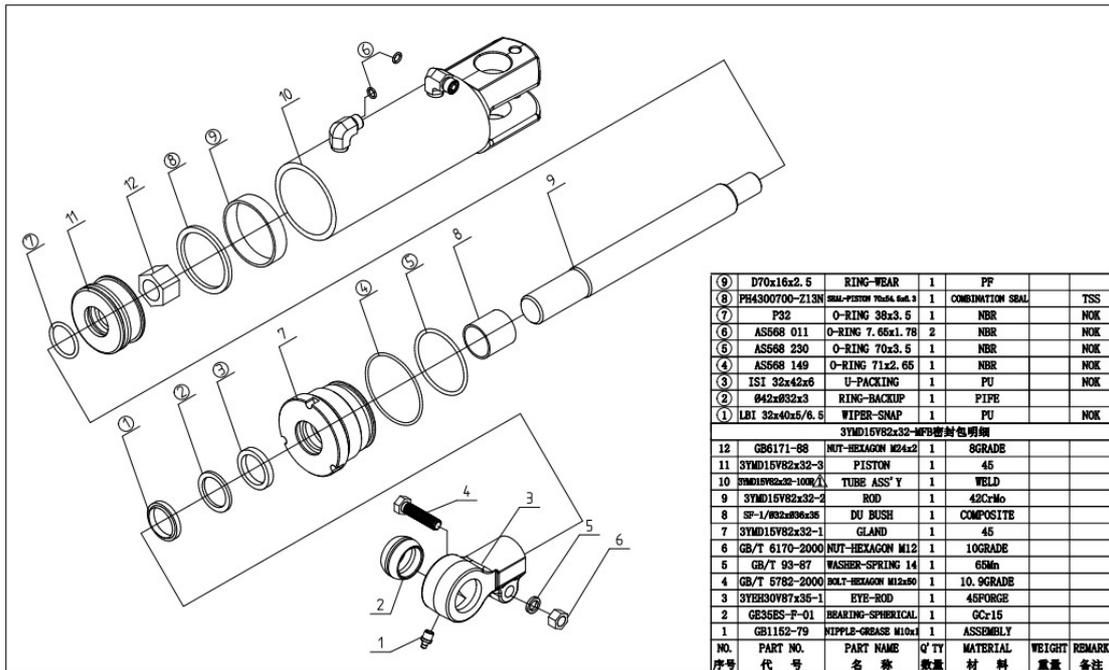
Put piston ring in hydraulic oil of 40-50°C, and expand inner diameter of the ring, and assemble it on piston. Install piston seal.

Bend and turn the edge of guide install guide.



3. TILT CYLINDER

1) STRUCTURE

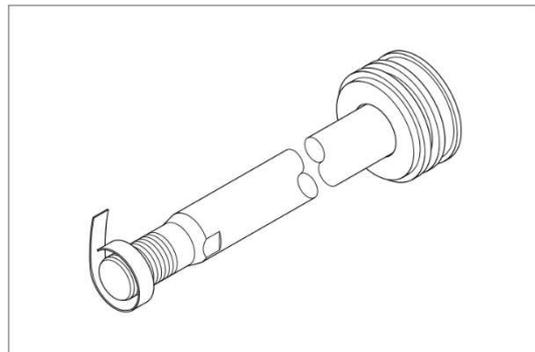


Inner diameter	Outer diameter	Stroke	Rod (outer diameter)
70mm	82mm	88mm	32mm

2) DISASSEMBLING

Hold flat area on the bottom of cylinder tube in vice, mark fastening torque on the end of rod head, and then separate rod head. Hook wrench on the notch of cylinder head, and then separate cylinder head from cylinder tube.

Wind valleys of thread of rod with adhesive tape to protect dust seal and rod seal inside cylinder head from damage.

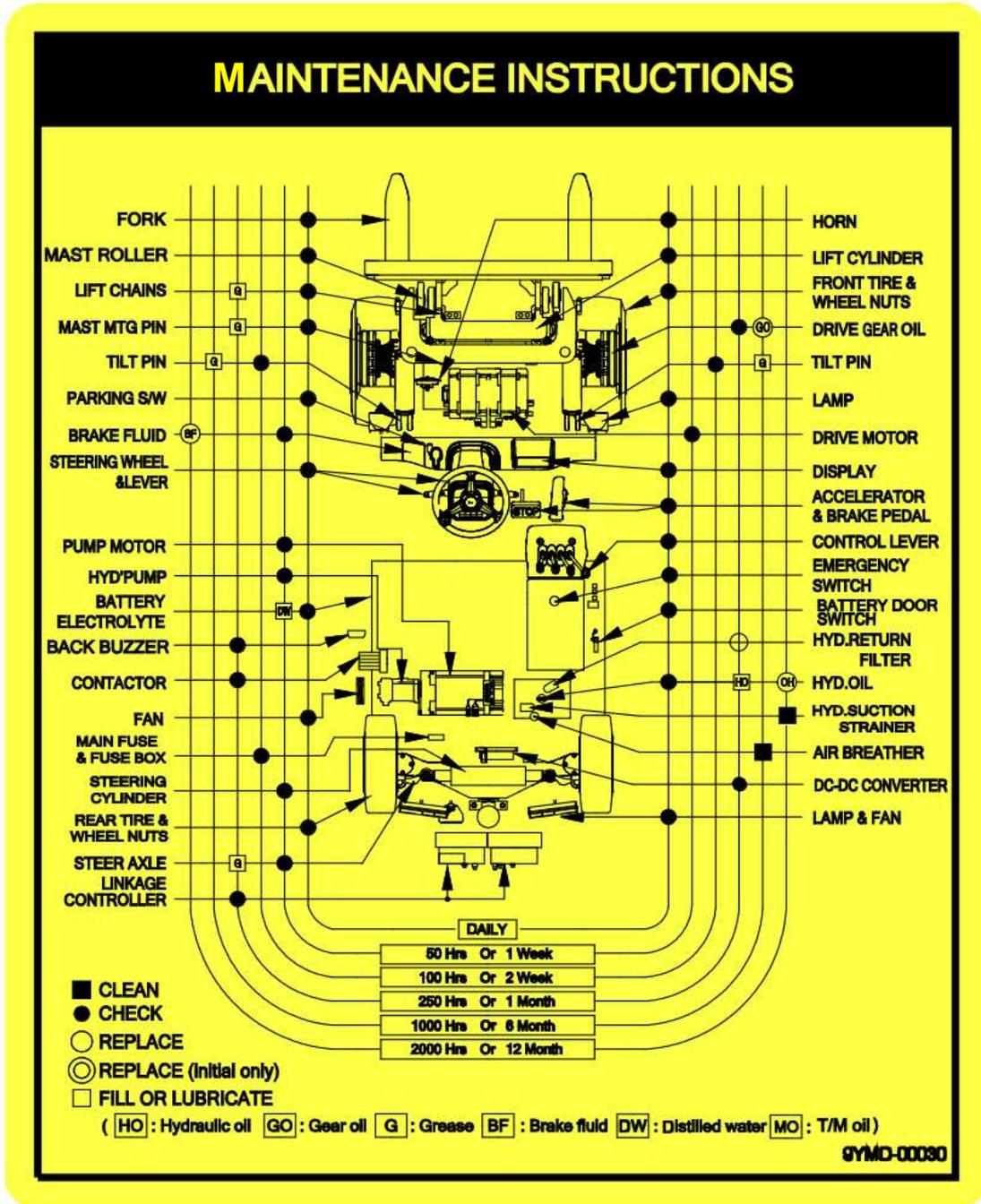


3) CHECKING AND INSPECTION

Inspection items	Standard dimensions	Limit on repair	Troubleshooting
Gap between cylinder rod and bushing	0.072 - 0.288mm	0.5mm	Replacing bushing
Gap between rod head bushing and pin	0.10 - 0.35mm	0.6mm	Replacing bushing

SECTION 7 ELECTRIC SYSTEM

GROUP 1 GENERAL LOCATIONS OF PARTS



GROUP 2 ELECTRIC CIRCUIT DIAGRAMS

1. CODES IN ELECTRIC CIRCUIT DIAGRAMS

Code	Name
00	Battery negative electrode
99	Negative electrode of DC-DC converter
T	Traction controller control signal
P	Pump controller control signal
JT	Emergency power-off switch
F	Fuse
D	Weighing sensor signal
N+	Heater positive wire harness
N-	Heater negative wire harness
K+	Air conditioner positive wire harness
K-	Air conditioner negative wire harness

GROUP 3 ELECTRIC FUNCTIONAL PARTS

1. FUNCTIONS OF POWER FORKLIFT TRUCK AND PARTS

The major functions of forklift truck are classified into two categories: Driving and loading/unloading. These functions operated by AC motor, which uses battery as power source, and requires battery charger, accordingly.

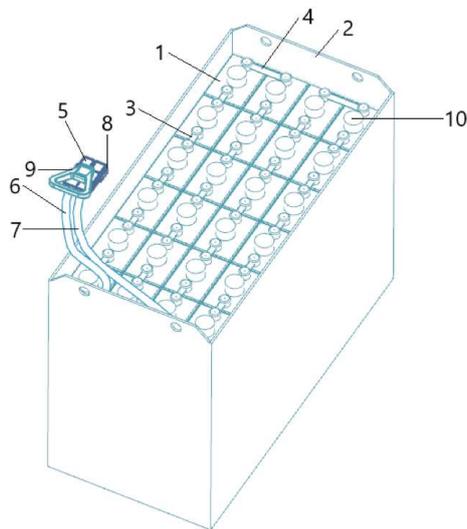
It is required to select driving direction by making use of electric components such as drive control system and direction switching lever (front/rear section switch), and to adjust speed drive motor to operate forklift truck.

Protection circuits are embedded in control system for protecting truck and components from failure. Monitoring system embedded in monitor panel monitors and shows conditions of truck and working to let operator take adequate actions, if required. Monitoring system is mounted with sensors such as current sensor, hydraulic pressure sensor and temperature sensor.

Forklift truck of HD HYUNDAI has operator-friendly features for adjusting conditions of truck dependent upon working environments at driver's seat by making use of the advanced drive control system. Self-diagnosis function displays current conditions of working truck, and provides environment for operation of truck in more efficient manner.

2. BATTERY

1) STRUCTURE



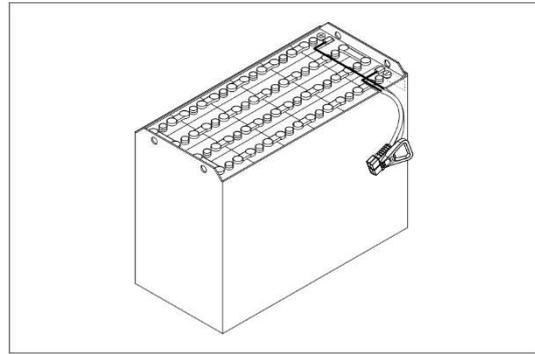
1 Cell	5 Terminal connector	8 Plug
2 Battery box	6 (+) Cable	9 Steering wheel
3 Connector	7 (-) Cable	10 Cap
4 Connector		

2) GENERAL

Battery is power source for battery-powered forklift truck, and careful handling of battery is very important.

Service life and capabilities of lift truck largely vary dependent upon routine handling and maintenance.

It is, therefore, must to ensure correct inspection and maintenance to keep battery at the best conditions.



3) SPECIFICATIONS AND SERVICING

Item	Unit	16/20BE-X
Type	-	Plumbic acid
Rated voltage	V	48
Capacity	AH/hr	420/5
Electrolyte	-	Wet
Dimensions (W×L×H)	mm	826×422×744
Connector (CE standard)	-	SB 350
Weight	kg	727

Specific gravity of fully charged battery	1.280 (25 ° C)
Specific gravity of fully discharged battery	1.120 (25 ° C)
Voltage at end of discharging	48V
Electrolyte	Refined thin sulfuric acid
Makeup solution	Purified water (distilled water)
Insulation resistance	1 MΩ

4) SAFETY PRECAUTIONS

① When skin contact with sulfuric acid

When skin, eyeball or clothes contacts with sulfuric acid, immediately flush with flowing water. If ingested, drink large volume of water or milk, and immediately see physician. Always wear safety goggles, face mask and rubber gloves when handling acid materials.

② Prevention of heat source, and ventilation

Battery produces explosive hydrogen. There should be heat source in the vicinity of battery. Open battery cover to ventilate before battery charging. Charging battery in confined space, explosion may take place.

③ Never put metal articles on the top of battery.

Metal article on battery may cause short circuit, especially during charging. Flame is equally dangerous open fires.

④ Handling of charger

When connecting or disconnecting a battery from a charger or attempting maintenance, make sure switches are all off. Ensure that the charger and the battery are matched. If a 300-Ah battery is used with a charger designed to charge a 500-Ah battery, it will severely overcharge the battery.

5) OPERATION PRECAUTIONS

① Avoid over-discharging

If over-discharged, it will be difficult to restore the batteries to the original state by recharge. In order to maintain the batteries in use for long period of time, it is recommended to use the batteries with discharge amount not exceeding 80% of the rated capacity. Further care should be taken for preventing the unit cell voltage from falling below 1.5V.

② Avoid over-charging

If overcharged, the rise in battery temperature will become excessive, resulting in deterioration of plates and other parts and markedly shortening of battery life.

③ Avoid excessive elevation of temperature

Be sure to open the cover of battery housing tray before charging. If there is a possibility of temperature to exceed 55°C, discontinue the charge operation temporarily, or reduce the charge current.

6) CHECKING

① Unpacking

Batteries are delivered to customers in dry-charged condition. At unpacking, check whether the batteries and accessories have been damaged. If there are observed defects, you should notify the condition to our branch office or agent. Never remove the sealing plug until the battery is put into service.

② Performance and maintenance of batteries

Initial charging

Battery gradually decreases its capacity during storage. In order to provide sufficient discharge capacity in the first discharge, the good initial charge is required. The conditions of initial charging are seen as below (at room temperature).

- By modified constant voltage charger
Connect the battery to the charger and turn on the equalizing charge "ON." The battery will be fully charged and terminated automatically.
- By constant voltage constant current charger (standard)
Connect the battery to the charger and turn on the equalizing charge "ON." The battery will be fully charged and terminated automatically.

Discharge and capacity

The capacity of batteries is indicated at 5 hours rate capacity which means the battery can be discharged for 5 hours with the discharge current calculated by dividing the capacity value by 5 until the unit cell mean voltage reaches down to 1.7V at the electrolyte temperature of 30°C. That is, the capacity is indicated by AH (ampere hour) being calculated as the product of ampere and time (H). However, even if it is the same type of batteries, the capacity varies with the discharge conditions (discharge current, battery temperature and specific gravity of electrolyte). Even if the batteries discharged its full capacity, if immediately charged to full, there will be no harmful effects remained. Ideal charging amount (AH) is 110-125% of the amount of previous discharge.

Specific gravity of electrolyte

Specific gravity of electrolyte drops at discharge and rises at charge. When the batteries are fully charged, it becomes almost constant and shows no further rise. The specific gravity value varies with the change in temperature. Therefore, specific gravity measurement should be made with temperature of electrolyte at the same so the measured specific gravity value could be corrected to that at the standard temperature of 25°C by the following formula.

$$S_{25} = S_t + 0.0007 (t-25)$$

S₂₅: Specific gravity at 25°C

S_t: Actual measured specific gravity at t°C

t: Electrolyte temperature (°C)

The standard specific gravity for this type of battery is 1.280±0.01 (25°C) at full charge condition. If the electrolyte decreases naturally while using, distilled water shall be replenished up to the specified level. (Never refill sulfuric acid).

Only when large quantity of electrolyte is lost due to spillage, etc., dilute sulfuric acid specified in gravity shall be added.

Normal charging

Charge the discharged batteries as quickly as possible. The temperature of electrolyte before starting the charging operation shall preferably be below 45°C, and the temperature during the charge should be maintained at no higher than 55°C. (Under any unavoidable situations, it should never be above 55°C). Methods of charging vary in precise meaning with the types of chargers used. A standard charging method is described hereunder. (If a special method is mentioned to be adopted, follow that instruction).

➤ Charging by modified constant voltage automatic charger

There is almost automatic charger today which completes the charging just only connecting the plug between battery and charger without outer operating timer. But if your charger has it, after setting the timer for 3-4 hours and turn on the charger and the charger is left as it is, then the charge will be made automatically. In principle, regardless of the amount of previous discharge, it is not required to alter the setting of timer time. The recommendable current value of this type of charger is "5 hours rate current × 1.0-1.5" at the start of charging, and at the final stage it is "5 hours rate current × 0.15-0.25". Normally the charge is terminated within 8~12 hours automatically.

Charging by constant current constant voltage automatic charger.

After a lapse of specified charging time after the switch is turned on, the charge will be completed by turning off the switch. The charging time can be calculated by the following formula:

Charging time = 2~3 (H) + Amount of previous discharge (AH) / Capacity of charger (A)

- When the amount of previous discharge is not known, use the 5 hours rate rated capacity of the batteries. At immediately after charging, the charge current is allowed up to 3 times 5 hours rate current. For charger provided with a timer, the charge will terminate automatically if the timer is set at the specified time according to the operation manual.

Charging by constant current charger

Connect the charger to the battery and charge the battery by 0.1C×5 hours rate nominal capacity current for 24 hours or more.

Equalizing charging

When large number of cells are used in a set of battery, the voltage and specific gravity of respective cells tend to become unequal, resulting in necessity of charging all the cells at an appropriate time in order to equalize them. This is called equalizing charge. Normally the equalizing charge should be carried out once every month. The methods are in normal type charger, extend the charge for 5 more hours after full charge at the final stage current, and in automatic charger which is in most cases provided with timer, extend the time setting for 3-6 more hours.

Replenishment of distilled water

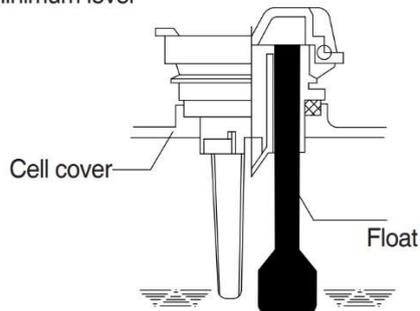
Only the water content of electrolyte is decreased due to electrolysis of distilled water during charge and natural evaporation. If a battery used with the electrolyte decreased excessively, plates will deteriorate resulting in markedly shortening of battery life. Be sure to check the electrolyte level once every week. If the electrolyte level is lowered, replenish distilled water up to the specified level. In this case, never attempt to replenish sulfuric acid or tap water. Use only distilled water for battery replenishment. If the amount of water required for weekly addition to a unit cell for 100 AH of battery capacity is in excess of 45 cc, it is assumed that the cell is receiving overcharge. Accordingly, be sure to reduce slightly the daily charge amount. Under the normal conditions, the addition of water per week is 45 cc or less. Incidentally, distilled water replenishment should be made before charging to the content of minimum level. (For the purpose of uniform stirring of electrolyte by charging).

If the electrolyte level is improper after completion of charging, you may top up the electrolyte level to the maximum level.

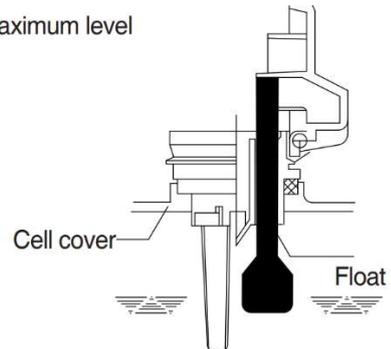
Determination of replenishment time and methods (cell with ONE TOUCH CAP)

Confirm the electrolyte level by looking at the float in the ONE TOUCH CAP. If too low as shown in figure, replenish distilled water. Replenishment shall be performed after opening the cover of the plug using syringe and jug. When refilling is completed, close each cover completely until "click" sound is heard

Minimum level



Maximum level



Cleaning

If electrolyte spills or the cells are polluted with dust or stains, it will cause generation of leak current. Wipe off dust and stains with moist cloth and clean in such a manner that the cells are kept in dry condition. In the case of plastic containers or covers, never use such organic solvents as paint thinner and gasoline. If used, the plastic containers or covers may suffer cracking. If you are forced to use them, be sure to use white kerosene.

Notice on charging

The charging area must be well ventilated to facilitate exhaust of gas generated from the battery during charging. Charge the battery in an area free from iron working, welding, etc. Further the battery generates hydrogen, oxygen, acid mist and on rare occasions, hydrogen sulfide during charging depending on the case. Special care may be required in the case of equipment and objects near the battery that may be contaminated or damaged. Do not pull out the charging plug during charging, as it will cause sparks. Since hydrogen gas generated during charging may remain in the area surrounding the battery after charging, never bring fire or flame close to this area. In case of counter-balance type vehicles, open the battery cover before charging.

Repair of failure cell

To remove a cell from the circuit or battery from steel tray, it is first necessary that the intercell connector be removed.

Before performing any repairs, you must open one-touch caps for gas purging of all cells. After you have finished that, must remove connector covers and on-touch caps from failure cell including surrounding cells. All vent holes of cells removed of one-touch caps must cover by four layers of water dampened cloth and then proceed with repairs. Using an acid syringe withdraw sufficient electrolyte from failure cell to reduce the liquid levels until minimum level indicating of one touch caps.

The safe and most effective way to remove the connector from the faulty unit and all surrounding units is the socket wrench.

- ⚠ You must make sure to clear of explosive hydrogen gas in the cells before repairs.

Remove the connector between batteries after removing the fixing bolts.

Lifted off the failure cell from circuit after removing of intercell connector.

Installing new cell and connector.

With surfaces properly cleaned and neutralized, position the connectors.

Fix and tighten the connecting cable between battery cells with M10 bolts with socket wrench, requiring torque of 25Nm.

When replacing electrolyte in a repaired cell, use sulfuric acid of the same specific gravity that is found in the balance of the battery.

Finally, rejoin connector covers and one-touch caps to the cells.

Summary of daily maintenance

Avoid overcharge. After discharge, charge the batteries immediately. The standard frequency of equalizing charge is more than once every month.

Be sure to check the electrolyte level once every week. If the electrolyte level is lowered, replenish distilled water up to the specified level.

The top surface of battery cells should be kept clean and dry.

Be sure to keep open the cover of battery housing tray during charge.

Never draw near open fires such as lighted cigarettes or burning matches during charge.

③ Others

Storage of batteries

When batteries are stored, keep them away from room heaters or other heat generating sources. Clean, cool and dry place where no direct sunlight is suited for battery storage. Before putting into storage, it is important to charge the batteries and keep the electrolyte level at the specified level.

When the temperature in storage location is higher than 20°C, check the specific gravity once a month, and when lower than 0°C, check it once every two months. If the measurements show values lower than 1.230 (20°C), it is required to charge the battery in accordance with the method described in NORMAL CHARGE.

Maintenance record

It is recommended to keep maintenance record in order to know the operational conditions of batteries. Daily charge and discharge, equalizing charge requirements, and distilled water replenishment requirements can be clarified at a glance. Measurements of specific gravity and temperatures once every two to four months after equalizing charge and maintenance thereof will serve for battery health diagnosis.

Electrolyte temperature (°C)

The operating temperature range of batteries is -10-45°C (temperature of electrolyte). If the batteries are exposed to cold atmosphere in discharged condition, the electrolyte may freeze, and in extreme cases, the capacity will be decreased, but, if not frozen, no adverse effects will be exerted.

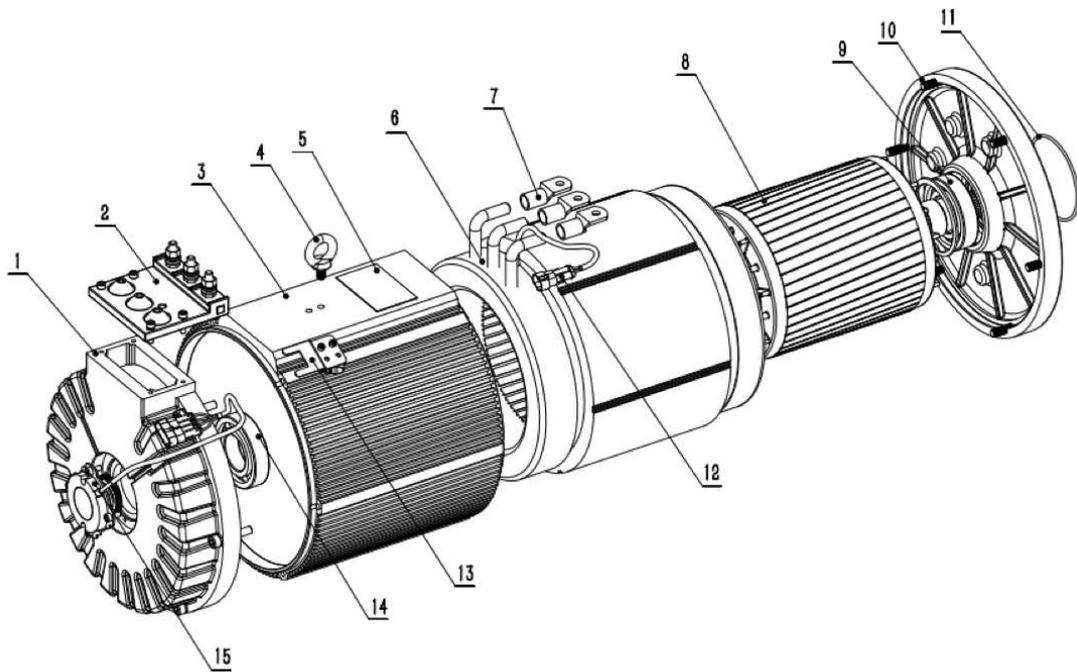
Contrarily if the temperature is high, especially if used at above 55°C, the battery life will be considerably shortened. Care must be taken so that the temperature during charge will be maintained at 55°C or lower. Even under unavoidable circumstances it should not exceed 55°C.

7) FAILURE DIAGNOSIS AND TROUBLESHOOTING

Nature of trouble	Symptoms	Causes	Corrective actions
Deformation	<ul style="list-style-type: none"> · Deformation of container Lid or one-touch cap 	<ul style="list-style-type: none"> · Excessive temperature rising or external impact 	<ul style="list-style-type: none"> · Replace.
Breakage	<ul style="list-style-type: none"> · Electrolyte leakage according to breakage of container, lid or one touch cap. · Termination of connector or pole post etc. 	<ul style="list-style-type: none"> · External impact, improper handling, excessive vibration · Excessive temperature rising or external impact 	<ul style="list-style-type: none"> · Replace or install a new one. · Replace.
Sulfate	<ul style="list-style-type: none"> · Specific gravity drops and capacity is decreased. · Charge voltage rises rapidly with immature gassing in earlier stage but specific gravity does not rise and charge can't be carried out. 	<ul style="list-style-type: none"> · When left in state of discharge or left long without equalizing charge. · Insufficient charge. · When electrolyte is so decreased that plate is deposited. · When concentration of electrolyte rises. · When impurities are mixed in electrolyte. 	<ul style="list-style-type: none"> · Need equalizing charge. · Need equalizing charge. · Need equalizing charge. · Adjust specific gravity. · Replace electrolyte.
Decrease and falling of specific gravity	<ul style="list-style-type: none"> · May be easily detected by measurement of the specific gravity. 	<ul style="list-style-type: none"> · Rise of temperature due to such trouble. · When left long period without refilling of water. Short circuit. 	<ul style="list-style-type: none"> · Replace. · Refill water in regular period. · Replace.
Rise of specific gravity	<ul style="list-style-type: none"> · May be easily detected by measurement of the specific gravity. 	<ul style="list-style-type: none"> · Diluted sulfuric acid is used in refilling. · When the electrolyte level excessively drops. 	<ul style="list-style-type: none"> · Adjust specific gravity after full charge. · Refill distilled water.
Mixing of impurities	<ul style="list-style-type: none"> · Decrease of capacity. · Drop of charge and discharge voltage. · Odor of generated gas and coloring of the electrolyte. 	<ul style="list-style-type: none"> · Metals such as iron, copper nickel and manganese. · Impurities such as sea water, chloric acid, nitric acid etc. · Filling of impure water. 	<ul style="list-style-type: none"> · Under a fully discharged condition, pour out the electrolyte. Then pour in an acid of the specific gravity higher by 0.03-0.05 than that of the drained acid. Charge fully and adjust the specific gravity to the specified value.

3. DRIVE MOTOR

1) STRUCTURE



- | | | | | | |
|---|-----------------|----|----------------------|----|-----------------------|
| 1 | REAR END COVRR | 6 | MOTOR STATOR | 11 | O SEAL RING |
| 2 | TERMINAL PANEL | 7 | THREE-PHASE TERMINAL | 12 | TEMPERATURE SENSOR |
| 3 | MOTOR SHELL | 8 | MOTOR ROTOR | 13 | SENSOR MOUNTING PLATE |
| 4 | LIFTING BOLT | 9 | FORE BEARING | 14 | REAR BEARING |
| 5 | MOTOR NAMEPLATE | 10 | FRONT END COVER | 15 | SPEED SENSOR |

2) SPECIFICATIONS

Item	Unit	16/20BE- X
Type	-	YST8H4-9-001
Rated voltage	Vac	29.5
Rated output	kW	9
Insulation	-	Grade H

3) CHECKING

① Rotor

Always clean the rotor with compressed air. If dust is not removed, wipe the rotor with soft cloth or cotton dampened with gasoline.

➤ Tools: Vernier calipers and standard tools

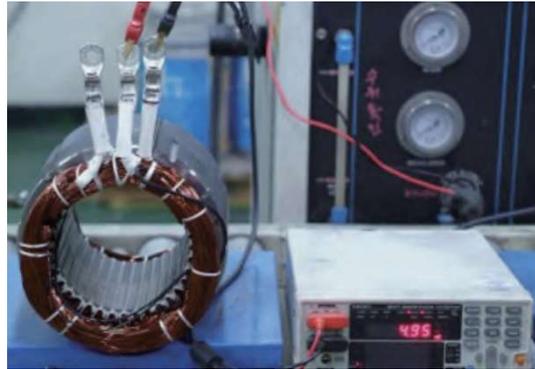
② Stator

Always clean the rotor with compressed air. If dust is not removed, wipe the stator with soft cloth or cotton dampened with gasoline while exercising care for protecting coil insulator from damage.

Repeat inspection of power source line 2 of the stator with meter-ohm gauge. (U-V, V-W, W-U)

➤ Proper resistance:

Ambient temperature 20-30°C,
resistance 2.47—2.73 MΩ.



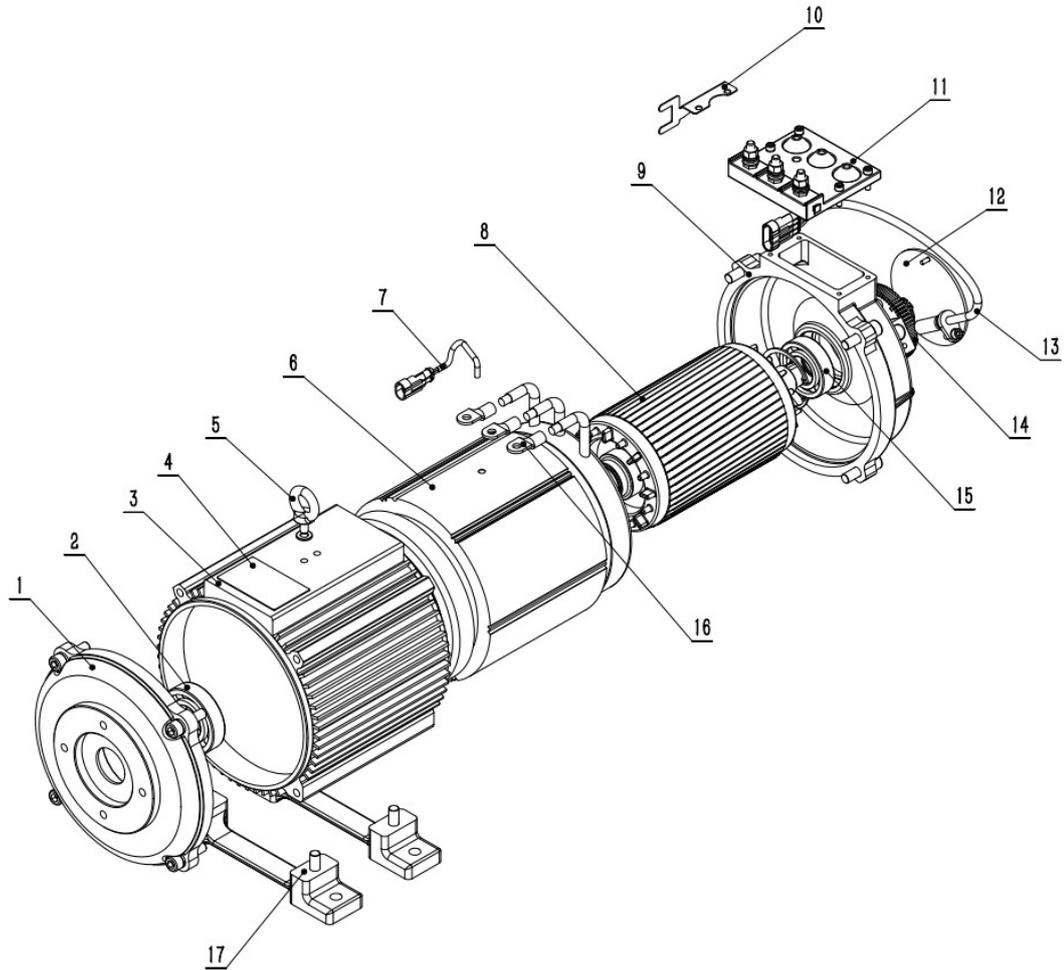
Measuring insulator

Make use of insulator gauge (1000V, min. 10 MΩ) to perform measurement as shown on the photo. Replace insulator with new part, if damaged.



4. PUMP MOTOR

1) STRUCTURE



1	FRONT END COVER	7	TEMPERATURE SENSOR	13	SPEED SENSOR
2	FORE BEARING	8	MOTOR ROTOR	14	PULSE WHEEL
3	MOTOR SHELL	9	REAR END COVRR	15	REAR BEARING
4	MOTOR NAMEPLATE	10	SENSOR MOUNTING PLATE	16	THREE-PHASE TERMINAL
5	LIFTING BOLT	11	TERMINAL PANEL	17	MOTOR FOOT
6	MOTOR STATOR	12	PULSE WHEEL COVER PLATE		

2) SPECIFICATIONS

Item	Unit	16/20BE-X
Type	-	YSP5H4-13-001
Rated voltage	Vac	29.5
Rated output	kW	13
Insulation	-	Grade H

3) INTERNAL INVOLUTE SPLINE DATA

Item		Unit	Specifications
Flat root side fit	No. of teeth	EA	10
	Pressure angle	Degree	30
	Spline pitch	-	16/32
	Major diameter	mm	17.463
	Form diameter	mm	13.749
	Minor diameter	mm	14.465
	Pin diameter	mm	2.743

4) CHECKING

① Rotor

Always clean the rotor with compressed air. If dust is not removed, wipe the rotor with soft cloth or cotton dampened with gasoline.

Tools: Vernier calipers and standard tools

② Stator

Always clean the rotor with compressed air. If dust is not removed, wipe the stator with soft cloth or cotton dampened with gasoline while exercising care for protecting coil insulator from damage.

Repeat inspection of power source line 2 of the stator with meter-ohm gauge. (U-V, V-W, W-U)

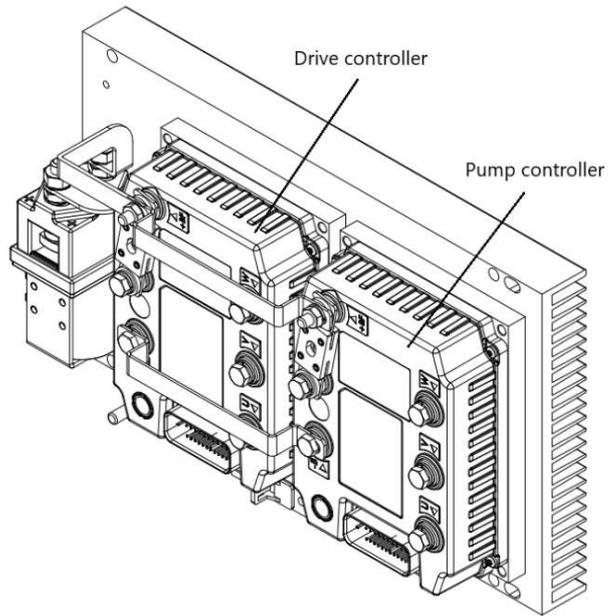
Proper resistance:

Ambient temperature 20-30°C, resistance 3.4—4.0 MΩ.

Measuring insulator: refer to Page 106 Measuring Stator of Drive Motor.

5. CONTROLLER SYSTEM

1) STRUCTURE



Model	Application	Type	Power	Current limit
ACE2 NEWGEN	16/20BE-X Traction	MOSFET	36-48V, 400A	400A/2 min
ACE2 NEWGEN	16/20BE-X Pump	MOSFET	36-48V, 400A	400A/2 min

2) OPERATIONAL FEATURES (TRACTION AND PUMP CONTROLLER)

The controller controls closed circuit speed and torque for induction (ACIM) and surface permanent magnet (SPM) motor.

Field-oriented motor control algorithm of high efficiency capable of exerting max. motor torque in any working environments.

Hi-end pulse-width modification technology ensuring efficient consumption of battery voltage, low motor harmonics, low torque ripple, and min. conversion loss.

Very large-scope torques and speeds including full playing function.

Smooth low-speed control including zero speed.

ACIM motor mitigating field, and SPM motor capable of controlling speeds including non-load basic speed.

Control algorithm is applied to motor temperature variation for keeping optimal capabilities in conditions of wide range and high diversity.

Power limit map reduces heat generated from motor, and is capable of satisfying capability requirements for keeping capability constant under various battery charging conditions.

The functions of overheat prevention, warning and auto stop protect motor and controller.

Power base of metal insulation substrate of excellent heat transfer enhances reliability.

Embedded auto characterization routine for optimizing trucks for motor capabilities and efficiency.

Powerful operating system is capable of performing control of truck and motor, and parallel processing of user-defined programmable logic (VCL).

Wide-range input/out are applied whenever required for controlling distributed systems to the largest extent.

Embedded dual drive software easily sets and controls of common dual drive trucks without VCL.

Battery charging indicator, hour meter and service timer.

CAN open compatible with CAN bus (CAN bus protocol configured through VCL).

Increased CAN master capabilities (VCL execution speed and code space).

Field programming mode allowing flash download of main operation codes.

Programming facilitated by Zapi PC CAN Console and Zapi Smart Console.

Stubbornly sealed housing and connector satisfy IP65 environmental sealing standards in severe environments.

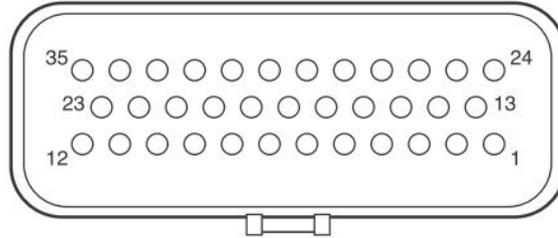
Compliant with EN1175:2020

3) DESCRIPTION OF THE CONNECTORS

① Traction and pump controller

Every low-power connection is connected through single 35-in AMPSEAL connector. Plug housing for coupling is AMP P/N 776164-1, and contact pin is AMP P/N 770520-3.

Connector accommodates 0.5-1.25 mm (20-16 AWG) wire having thin wall insulator of 1.7-2.7 mm diameter. The wire is sealed in unused connector of silo-diagram together with seal plug 77068-1.



PIN	NAME	DESCRIPTION
1	EVP POT	Analog input 3. The default function is as lowering reference (wiper contact of the lowering potentiometer)
2	AUX1	Digital input, active when connected to +B. By default, closing the switch output NEV1 (Pin24) is activated.
3	KEY	Input of the key switch signal.
4	PPOT	Positive supply for potentiometers (+5 V or +12 V, 200 mA maximum).
5	ACC POT	Analog input 1. The default function is as accelerator reference (wiper contact of the accelerator potentiometer).
6	FW	Digital input active when connected to +B. The default function is as forward request: closing this input the truck moves forward.
7	BW	Digital input active when connected to +B. The default function is as backward request: closing this input the truck moves backward.
8	SEAT	Digital input active when connected to -B. The default function is as seat (or tiller) input.
9	CHA	Channel A of the incremental encoder.
10	PENC	Positive supply for the encoder or for another speed transducer (+5 V or +12 V, 200 mA maximum).
11	LOWER	Digital input, active when connected to -B. The default function is as lowering request. Closing the switch, NEVP output (Pin29) is activated according to the setpoint defined by EVP POT (Pin1).
12	AUX2	Digital input, active when connected to +B. By default, closing the switch output NEV2 (Pin25) is activated.
13	STEER POT	Analog input 4. The default function is as steering reference (wiper contact of the steering potentiometer).

PIN	NAME	DESCRIPTION
14	AUX3	Digital input, active when connected to +B. By default, closing the switch output NEV3 (Pin34) is activated.
15	NPOT	Negative supply for the potentiometers.
16	BRK POT	Analog input 2. The default function is as breaking reference (wiper contact of the brake potentiometer).
17	QI/PB	Digital input active when connected to +B. The default function is as quick-inversion or brake-pedal input.
18	CANT	If connected to Pin31 (CANH), it introduces the 120 Ohm termination resistance between CANL and CANH.
19	SR/HB	Digital input inactive when connected to -B, active when the switch is open. The default function is as speed-reduction or handbrake request.
20	CHB	Channel B of the incremental encoder.
21	NENC	Negative supply for the encoder. By default, it is to be used as negative terminal for the thermal sensor too.
22	BACK. FW	Digital input, active when connected to +B. The default function is as forward backing (inching) request.
23	BACK. BW	Digital input, active when connected to +B. The default function is as backward backing (inching) request.
24	PIN	Positive supply for the high-side driver of pin PEB (Pin27). By default, it is to be connected after the main contactor connecting.
25	NEV1	Driving output for the on/off electric valve EV1 (driving to -B); PWM voltage controlled; 1.5 A maximum continuous current.
26	NLC	Driving output for the line - or main - contactor (driving to -B); PWM controlled; 2 A maximum continuous current.
27	PEB	Positive supply for the electromechanical brake and the electric valve. It is supplied by PIN (24) through a high-side driver.
28	NEB	Driving output for the electromechanical brake (driving to -B); PWM controlled; 3 A maximum continuous current.
29	NEVP	Driving output for the proportional electric valve (driving to -B); PWM current-controlled; 1.7 A maximum continuous current. Default function is as LOWERING valve.
30	CANL	Low-level CAN bus line.
31	CANH	High-level CAN bus line.
32	NCAN	CAN bus negative reference. To be used only in case of isolated CAN bus.
33	PTHERM	Analog input for the thermal sensor of the traction motor. Internal pull-up is 2 mA current source (max 5 V).
34	NEV2	Driving output for the on/off electric valve EV2 (driving to -B); 1.5 A maximum continuous current.
35	NEV3	Driving output for the on/off electric valve EV3 (driving to -B); 1.5 A maximum continuous current.

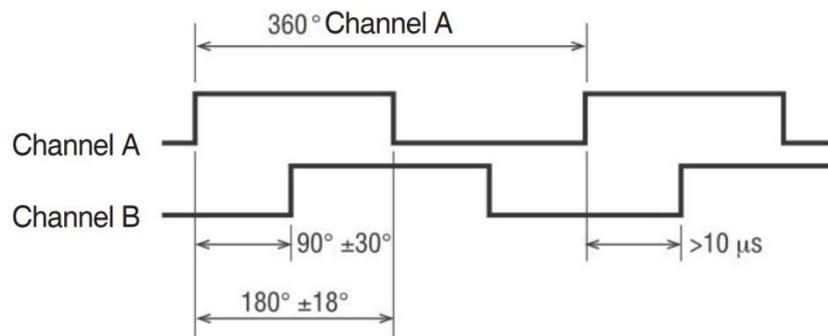
② Encoder connection (drive and pump)

Two control lines are configured inside for reading quadrature type position encoder.

Power supply of encoder is commonly 5V or 12V (Pin 10), and power can be supplied by 5V - B+ by external source only when logic critical value is satisfied.

PIN	NAME	DESCRIPTION
10	+ 5 V	Power supplying to positive electrode of encoder
21	GND	Power supplying to negative electrode of encoder
9	ENC A	Encoder A phase
20	ENC B	Encoder B phase

These signal tolerances should be within operating conditions of application including scope of voltage, temperature, speed and torque.



4) PROGRAMING AND ADJUSTMENT

It is allowed to adjustment parameters through Zapi Smart Console programmer.

Adjusting with portable programmer (opt)



Connect to the main harness of the lift truck.

※ Turn Start key to OFF position, and then make connection and release.

① Operational Modes

Smart Console has been designed to have multiple ways of operation. Three modes can be identified:

- Serial connection powered by four standard AA size batteries placed in the battery holder of the console.
- CAN bus connection powered by four standard AA size batteries placed in the battery holder of the console.
- CAN bus connection with Smart Console supplied by an external dc source. This source may be a standard battery (lead-acid or other type) or a DC/DC converter

Current-loop serial connection

Smart Console offers the same serial connection as the well-known Console Ultra.

Main features of this operational mode are:

- Current-loop serial communication.
- Console is connected to a single controller only (even if Remote Console option is available).
- Selectable baud-rate.
- Zapi can provide the serial cable compatible with Molex SPOX connector used in Console Ultra.

CAN bus connection

The Smart Console can connect to an existing CAN line and connect with any Zapi controller inside this line.

Main features of this operational mode:

- It can be connected to a CAN line composed of any combination of modules, both Zapi ones and non-Zapi ones;
- Supported speeds: 125, 250, 500 kbps;
- It sees the entire CAN line and all CAN modules.

② The keyboard

The keyboard is used to navigate through the menus. It features some keys with special functions and a green LED. Different button functions are shown below.

UP and DOWN keys

In most cases a menu is a list of items: these items are ordered in rows. The selected item is highlighted in light blue. Up and down keys are used to move the selection up and down: others are used to roll or scroll the menu.

LEFT and RIGHT keys

Normally used to increase and decrease the value associated with the selected item.

OK and ESC keys

OK key is used either to confirm actions or to enter a submenu. ESC is used either to cancel an action or to exit a menu.

F1, F2, F3 keys

These buttons have a contextual use. The display will show which F button can be used and its function.

ON key

Used while operating with internal batteries.

Green LED

When the console is powered running the green LED is on. Green LED can blink in certain cases which will be described better in the following sections.

③ Home Screen

After showing the Zapi logo, the HOME SCREEN will appear on the display:

From top:

- First line tells which firmware version is running inside the console, in this case ZP 0.15.
- RS232 Console: enter this menu to start a serial connection as in the Console Ultra.
- CAN Console: enter this menu to establish a CAN connection. • AUTOSCAN CAN: another way to establish a CAN connection.
- Console Utilities and Menu Console: ignore them at the moment.
- The current hour is shown at the bottom right.



Moreover, the green LED is on and still.

The "RS232" line is already highlighted at the start-up. Press OK key to start a serial connection. Display prompts a message to inform you that a connection attempt is ongoing. If serial connection fails a "NO COMMUNICATION" warning will be shown after some seconds: press ESC key and look for what is preventing the connection.

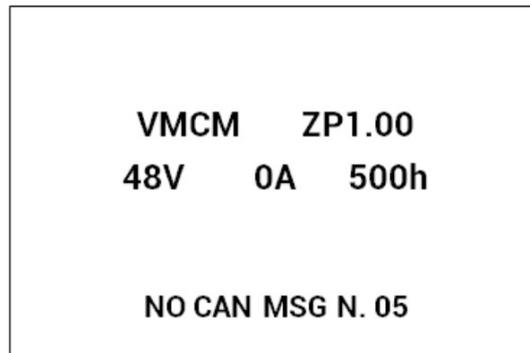
Please notice the red dot appearing on the top right of the display every time you press a button. It indicates that the console has received the command and it is elaborating the request. If the red dot does not appear when a button is pressed, there is probably a failure inside the keyboard or the console has stalled.

④ Connected

If connection is successful, the display will show a page similar to the next one.

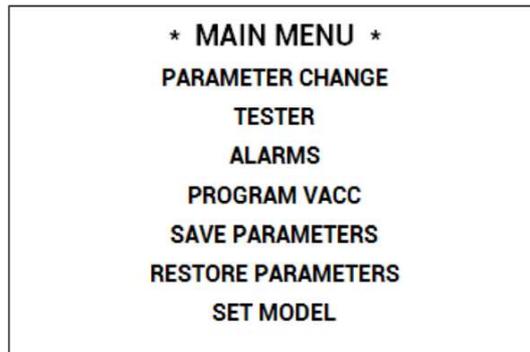
This menu shows basic information about the controller, in a similar way to the console Ultra.

- First line displays the controller firmware.
- Second line shows controller voltage, controller current and hour meter.
- Last line shows the current alarm code, if present.



Press OK to access the MAIN MENU.

MAIN MENU contains the complete list of menus available in the controller. Contrary to Console Ultra there are no "hidden" menus which must be reached by some combinations of buttons: here all menus are visible. Use UP and DOWN keys to navigate the list: once you find the desired menu press OK to enter it.



⑤ How to modify parameters

From MAIN MENU enter the desired menu (for example the PARAMETER CHANGE menu).

With UP and DOWN keys you can scroll the list: once you have highlighted the parameter you want to modify, press either LEFT or RIGHT keys to decrease or increase the parameter value.

Keep LEFT/RIGHT button pressed to continuously repeat the value modification ("auto-repeat" function): this function will speed up the procedure in case many parameter values must be changed.

You can press ESC to exit the menu at any time. In case parameters have been modified, the console will prompt the request to confirm/discard changes.

Description above is valid for every menu which contains parameters and options like SET OPTIONS, ADJUSTMENT, HARDWARE SETTINGS, etc.

PARAMETER CHANGE	
ACCELER DELAY	1.0
E. ACCELER. DELAY	1.5
SPEED LIMIT BRK	2.2
E. SPD. LIMIT BRK	2.2
RELEASE BRAKING	4
E. RELEASE BRAKING	2.5
CURVE BRAKING	3

PARAMETER CHANGE	
ACCELER DELAY	1.0
E. ACCELER. DELAY	1.5
SPEED LIMIT BRK	2.2
E. SPD. LIMIT BRK	2.2
RELEASE BRAKING	4
E. RELEASE BRAKING	2.5
CURVE BRAKING	3

APPLY CHANGES?

YES=OK NO=ESC

⑥ PROGRAM VACC

PROGRAM VACC menu has been slightly modified from old consoles. Upon entering this menu, the console shows the current programmed values.

When OK is pressed, PROGRAM VACC procedure starts. Console invites you:

- to select the enable switch, if any;
- to select the direction switch (either forward or backward):
- to depress the pedal to its maximum excursion.

Displayed values vary accordingly to operator inputs.

Sequence above can slightly vary depending on controller firmware. The logic remains the same: before programming the min/max values, execute any starting sequence which is necessary, then press the pedal or push the joystick.

When ESC is pressed, console asks if programmed values must be saved or discarded.

PROGRAM VACC	
CURRENT VALUES	
MAX	5.0
MIN	0.3
PRESS OK FOR SETUP	

PROGRAM VACC		
FORWARD	0.0	4.5
BACKWARD	0.2	4.4
SEL. ENABLE AND DIRECTION		
THEN PRESS PEDAL		
(ESC TO FINISH)		

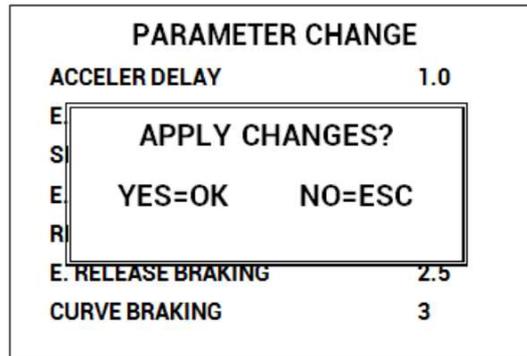
⑦ Lift and Lower acquisition

From MAIN MENU go into the Adjustment menu. With UP and DOWN keys you can scroll the list: once you have highlighted a value you want acquire, press OK. When OK is pressed, the procedure starts:

- select the Enable switch, if any;
- select the control switch if any (either lift or lower);
- move the control sensor (lift/lower potentiometer) to the correct position according to what you are acquiring.

Displayed values vary accordingly to operator inputs.

Sequence above can slightly vary depending on controller firmware. The logic remains the same: before programming the min/max values, execute any starting sequence which is necessary, then press the pedal or push the joystick.



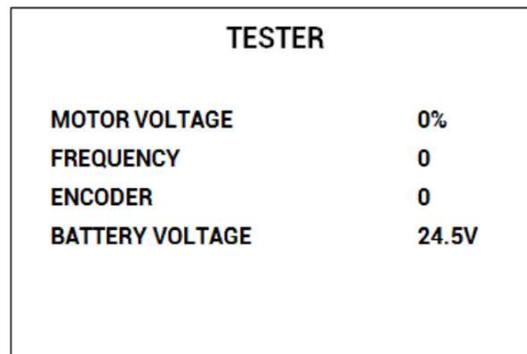
It is possible to acquire all the values in only one session. At the end you can press ESC and the console will prompt a request to confirm/discard changes.

⑧ Steer acquisition

From MAIN MENU go into the Adjustment menu. The procedure to follow is the same described in previous paragraph.

⑨ Tester

Compared to standard console Ultra, the TESTER menu has been deeply modified. Now it shows four variables at once: use UP/DOWN keys to scroll the list.

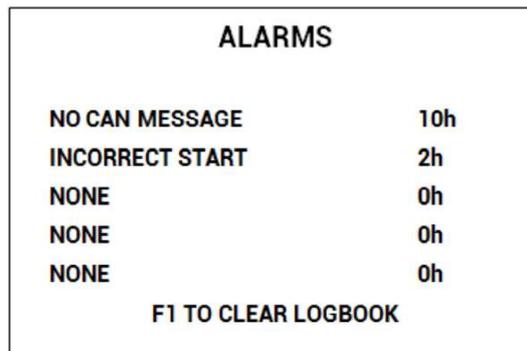


⑩ Alarms

ALARMS menu has changed from Console Ultra. Display shows all controller alarms at once.

Five is the maximum number of alarm codes which is stored inside the controller. Colors are used to separate recurrent alarm codes from rare events. In order of increasing frequency, alarm names can be:

- White: up to 5 occurrences
- Yellow: up to 20,



- Orange: up to 40,
- Red: more than 40.

Use UP/DOWN to select a certain alarm in the list: if OK is pressed, additional pieces of information about that alarm are displayed.

Press F1 to clear the alarm logbook of the controller: once F1 is pressed, the console asks for confirmation.

⑪ Download parameter list into a USB stick

When Smart Console is connected to a controller, it has the possibility to download all parameters into a USB stick. To use this function, go into the menu SAVE PARAMETER USB in the MAIN MENU.

File format

The complete list of parameters is saved as a csv file in order to be opened with Microsoft Excel® or any other spreadsheet tool.

The file is formatted in the same way as if it has been created with the PC CAN Console. Thus, it contains the whole list of parameters and, for each one, various data are available, in particular:

- Parameter value as it is saved within controller ("Value" column).
- Parameter value as it is shown by console or similar tools ("Scaled Value" column).
- Name of the menu where parameter is placed tools ("Name menu" column).

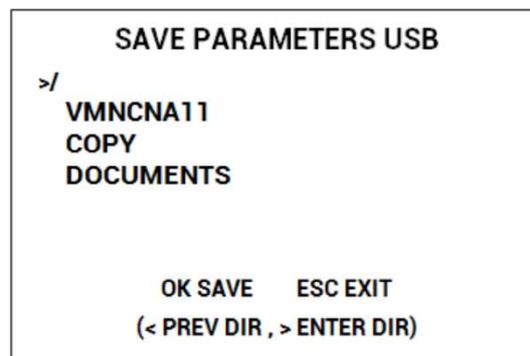
File name is generated as a hexadecimal code of the time and date of save. This codification prevents any overwrite of previously saved files.

Download procedure

After entering SAVE PARAMETER TO USB, the Smart Console checks the presence of a USB stick. If the stick is not connected, it asks the operator to connect one.

When the stick is present, the display shows the content, starting from the root directory (/) of the filesystem. Display looks like the following picture.

Notice that only directories are shown, not single files.



While exploring the content, the navigation buttons work in the following way:

- Up/down keys scroll the list.
- Right key explores the highlighted directory: its content (directories only) will be shown immediately.
- Left key returns one level back in the directory tree: it does not work in the root directory.
- Esc returns to HOME SCREEN.
- OK starts download.

When saving files, the console creates a subdirectory whose name has eight digits:

- First four digits are controller type.
- Fifth and sixth digits are the customer identification code.
- Seventh and eight digits are the code of the software installed inside the controller.

An example of this code is the first directory name (VMNCNA11) shown in the previous figure. If parameters are downloaded multiple times from the same controller, or from another controller whose eight codes are the same, all parameter files are saved in the same location. If the directory does not exist, it is created when download is carried out for the first time.

To download parameters, proceed as follows:

- Navigate the directory list and go into the directory where you want to save the parameters.
- If this directory already contains the subdirectory with the correct 8 digits go to step3. If it is not present, a new subdirectory will be created automatically. Do not enter the subdirectory manually.
- Press OK to start parameter download. A progression bar shows the ongoing process.
- When finished, press ESC so to return to MAIN MENU. USB stick can be removed safely.

Connect the USB stick to a PC and enter the directory of point 1). A subdirectory with the correct name and, inside this one, a csv file is present.

During download the led blinks slowly to indicate the console is running. When download has finished USB stick can be unplugged safely.

▲ Do not remove USB stick during download or the file will result empty or corrupted.

5) SAFETY INSTRUCTIONS

- Make sure that battery is disconnected before use.
- Driving wheel should be prompted or deactivated during driving to prevent unexpected operation or moving in wrong direction during initial startup of the truck. Open the valve during hydraulic operation to prevent excessive rise of pressure if the relief valve pressure malfunctions.
- Prerequisite actions should be taken for safety for ensuring prevention of damage to workers or equipment.
- The inside battery is kept charged for a certain period even when the key switch is kept open after starting operation. Separate the battery for safety drive, and use resistance of 10-100 Ω to make short circuit between power terminals of positive and negative electrodes of the inverter battery.

6) ALARM CODE

Drive and pump controller

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
209	PARAM RESTORE	O	O	Cause: The controller has restored the default settings. If a CLEAR EEPROM has been made before the last key recycle, this warning informs you that EEPROM was correctly cleared.	Symptom: No effect. Troubleshooting: A travel demand or a pump request cancels the alarm. If the alarm appears at key-on without any CLEAR EEPROM performed, replace the controller.
244	WARNING SLAVE	O	O	Cause: Warning on supervisor uC.	Symptom: It depends on the supervisor uC. Troubleshooting: Connect the Console to the supervisor uC and check which alarm is present.
17	LOGIC FAILURE #3	O	O	Cause: A hardware problem in the logic board due to high currents (overload). An overcurrent condition is triggered even if the power bridge is not driven.	Symptom: MC is opened, EB is applied, traction/pump stopped. Troubleshooting: The failure lies in the controller hardware. Replace the controller.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
60	CAPACITOR CHARGE	O	O	<p>Cause: When the key is switched on, the inverter tries to charge the power capacitors through the series of a PTC and a power resistance, checking if the capacitors are charged within a certain timeout. If the capacitor voltage results less than a certain percentage of the nominal battery voltage, the alarm is raised and the main contactor is not closed.</p>	<p>Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped.</p> <p>Troubleshooting: Check if an external load in parallel to the capacitor bank, which sinks current from the capacitors-charging circuit, thus preventing the caps from charging well. Check if a lamp or a DC/DC converter or an auxiliary load is placed in parallel to the capacitor bank. The charging resistance or PTC may be broken. Insert a power resistance across line-contactor power terminals; if the alarm disappears, it means that the charging resistance is damaged. The charging circuit has a failure or there is a problem in the power section. Replace the controller.</p>
30	VMN LOW	O	O	<p>Cause1: Start-up test. Before switching the LC on, the software checks the power bridge: it turns on alternatively the high-side power MOSFETs and expects the phase voltages increase toward the positive rail value. If one phase voltage is lower than a certain percentage of the rail voltage, this alarm occurs.</p> <p>Cause2: Motor running test. When the motor is running, the power bridge is on and the motor voltage feedback tested; if it is lower than expected value (a range of values is considered), the controller enters in fault state</p>	<p>Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped.</p> <p>Troubleshooting: If the problem occurs at start up (the LC does not close at all), check: motor internal connections (ohmic continuity); motor power-cables connections; if the motor connections are OK, the problem is inside the controller; replace it. If the alarm occurs while the motor is running, check: motor connections; that the LC power contact closes properly, with a good contact; if no problem is found, the problem is inside the controller. Replace it.</p>

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
74	DRIVER SHORTED	O	O	Cause: The driver of the LC coil is shorted.	Symptom: MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped. Troubleshooting: Check if there is a short or a low impedance pull-down between NLC (pin A12) and -B. The driver circuit is damaged: replace the logic board.
235	CTRAP THRESHOLD	O	O	Cause: This alarm occurs when a mismatch is detected between the setpoint for the overcurrent detection circuit (dependent on parameter DUTY PWM CTRAP, see paragraph 8.2.4) and the feedback of the actual threshold value.	Symptom : MC is opened, EB is applied, Traction/Pump, valves stopped. Troubleshooting: The failure lies in the controller hardware. Replace the logic board.
31	VMN HIGH	O	O	Cause: Before closing the LC, the software checks the power bridge voltage without driving it. The software expects the voltage to be in a "steady state" value. If it is too high, this alarm occurs. The hexadecimal value "XX" identifies the faulty phase: 81: phase U 82: phase V 83: phase W.	Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting : Check the motor power cables. Check the impedance between U, V and W terminals and -B terminal of the controller. Check the motor leakage to truck frame. If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller. Replace it.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
226	VACC OUT RANGE	O	O	Cause: The CPOT input read by the microcontroller is not within the MIN VACC ÷ MAX VACC range, programmed through the PROGRAMM VACC function (see paragraph 9.1). The acquired values MIN VACC and MAX VACC are inconsistent.	Symptom: Traction/Pump motor is stopped. Troubleshooting: Acquire the maximum and minimum potentiometer values through the PROGRAM VACC function. If the alarm is still present, check the mechanical calibration and the functionality of the accelerator potentiometer. If the problem is not solved, replace the logic board.
53	STBY I HIGH	O		Cause: In standby, the sensor detects a current value different from zero.	Symptom: MC is not closed, EB is applied, Traction/Pump stopped. Troubleshooting: The current sensor or the current feedback circuit is damaged. Replace the controller.
38	CONTACTOR OPEN	O		Cause: The LC coil is driven by the controller, but it seems that the power contacts do not close. In order to detect this condition the controller injects a DC current into the motor and checks the voltage on power capacitor. If the power capacitors get discharged it means that the main contactor is open.	Symptom : MC is opened, EB is applied, Traction/Pump, valves stopped. Troubleshooting: LC contacts are not working. Replace the LC. If LC contacts are working correctly, contact a Zapi technician.
86	PEDAL WIRE KO	O	O	Cause: This alarm is signaled if a fault is detected in the accelerator unit wiring (NPOT or PPOT cable is interrupted).	Symptom: T86 Fault performance Traction is stopped: P86 Fault performance Lift stop. Troubleshooting : Replace the accelerator or increase the potentiometer.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
254	EB. DRIV.SHRT.	O	O	Cause: The EB driver is shorted. The microcontroller detects a mismatch between the setpoint and the feedback at the EB output.	<p>Symptom: MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped.</p> <p>Troubleshooting: Check if there is a short or a low impedance path between the negative coil terminal and -B. Check if the voltage applied is in accordance with the settings of the EB-related parameters (see paragraph 8.2.5). If the problem is not solved, replace the controller.</p>
19	LOGIC FAILURE #1	O	O	Cause: This fault is displayed when the controller detects an undervoltage condition at the KEY input (pin A3). Undervoltage threshold is 11V for 24V and 36/48V controllers.	<p>Symptom: MC is opened, EB is applied, traction/pump stopped.</p> <p>Troubleshooting (fault at startup or in standby): Fault can be caused by a key input signal characterized by pulses below the undervoltage threshold, possibly due to external loads like DC/DC converters starting-up, relays or contactors during switching periods, solenoids energizing or de-energizing. Consider to remove such loads. If no voltage transient is detected on the supply line and the alarm is present every time the key switches on, the failure probably lies in the controller hardware. Replace the logic board.</p> <p>Troubleshooting (fault displayed during motor driving): If the alarm occurs during motor acceleration or when there is a hydraulic-related request, check the battery charge, the battery health and power-cable connections.</p>

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
18	LOGIC FAILURE #2	O	O	Cause: Fault in the hardware section of the logic board which deals with voltage feedbacks of motor phases.	Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting: The failure lies in the controller hardware. Replace the controller.
243	THROTTLE PROG.	O	O	Cause: A wrong profile has been set in the throttle profile.	Symptom: MC remains closed, EB is applied (the command is released), Traction stopped. Troubleshooting: Set properly the throttle-related parameters.
80	FORW + BACK	O		Cause: This alarm occurs when both the travel requests (FW and BW) are active at the same time.	Symptom: Traction is stopped. Troubleshooting: Check that travel requests are not active at the same time. Check the FW and BW input states through the TESTER function. Check the wirings relative to the FW and BW inputs. Check if there are failures in the microswitches. If the problem is not solved, replace the logic board.
79	INCORRECT START	O	O	Cause: Incorrect starting sequence. Possible reasons for this alarm are: - A travel demand active at key-on. - Man-presence sensor active at key on.	Symptom: Traction/Pump motor is stopped. Troubleshooting: Check the states of the input at key-on. Check wirings and the microswitches for failures. Through the TESTER function, check the states of the inputs are coherent with microswitches states. If the problem is not solved, replace the logic board.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
78	VACC NOT OK	0	0	Cause: At key-on and immediately after that, the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading (in TESTER function) is above the minimum value acquired during the PROGRAM VACC procedure.	Symptom: Traction/Pump motor is stopped. Troubleshooting: Check the wirings. Check the mechanical calibration and the functionality of the accelerator potentiometer. Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function. If the problem is not solved, replace the logic board.
75	CONTACTOR DRIVER	0	0	Cause: The LC coil driver is not able to drive the load. The device itself or its driver circuit is damaged.	Symptom: MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped. Troubleshooting: This type of fault is not related to external components; replace the logic board.
62	TH. PROTECTION	0	0	Cause: The temperature of the controller base plate is above 85 ° C. The maximum current is proportionally decreased with the temperature excess from 85 ° C up to 105 ° C. At 105 ° C the current is limited to 0 A.	Symptom: Traction controller reduces the max current linearly from I _{max} (85° C) down to 0 A (105° C). Troubleshooting: It is necessary to improve the controller cooling. To realize an adequate cooling in case of finned heat sink important factors are the air flux and the cooling-air temperature. If the thermal dissipation is realized by applying the controller base plate onto the truck frame, the important factors are the thickness of the frame and the planarity and roughness of its surface. If the alarm occurs when the controller is cold, the possible reasons are a thermal-sensor failure or a failure in the logic board. In the last case, it is necessary to replace the controller.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
66	BATTERY LOW	O	O	Cause: Parameter BATTERY CHECK is other than 0 (SET OPTION list, paragraph 8.2.2) and battery charge is evaluated to be lower than BATT.LOW TRESHLD.	<p>Symptom: According to parameter BATTERY CHECK.</p> <p>Troubleshooting: Check the battery charge and charge it if necessary. If the battery is actually charged, measure the battery voltage through a voltmeter and compare it with the BATTERY VOLTAGE reading in the TESTER function. If they are different, adjust the ADJUST BATTERY parameter with the value measured through the voltmeter. If the problem is not solved, replace the logic board.</p>
221	HANDBRAKE	O		Cause: Handbrake input is active.	<p>Symptom: Traction/Pump motor is stopped.</p> <p>Troubleshooting: Check that handbrake is not active by mistake. Check the SR/HB input state through the TESTER function. Check the wirings. Check if there are failures in the microswitches. If the problem is not solved, replace the logic board.</p>
65	MOTOR TEMPERAT.	O	O	Cause: This warning occurs when the temperature sensor is open (if digital) or if it has overtaken the MAX. MOTOR TEMP. threshold (if analog).	<p>Symptom: Maximum current is linearly reduced and speed is reduced to a fixed value.</p> <p>Troubleshooting: Check the temperature read by the thermal sensor inside the motor through the MOTOR TEMPERATURE reading in the TESTER function. Check the sensor ohmic value and the sensor wiring. If the sensor is OK, improve the cooling of the motor. If the warning is present when the motor is cool, replace the controller.</p>

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
251	WRONG SET BAT	O	O	Cause: At start-up, the controller checks the battery voltage (measured at key input) and it verifies that it is within a range of $\pm 20\%$ around the nominal value.	<p>Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped.</p> <p>Troubleshooting: Check that the SET BATTERY parameter inside the ADJUSTMENTS list matches with the battery nominal voltage. If the battery nominal voltage is not available for the SET BATTERY parameter inside the ADJUSTMENTS list, record the value stored as HARDWARE BATTERY RANGE parameter in the SPECIAL ADJUST. list and contact a Zapi technician. Through the TESTER function, check that the KEY VOLTAGE reading shows the same value as the key voltage measured with a voltmeter on pin A3. If it does not match, then modify the ADJUST BATTERY parameter according to the value read by the voltmeter. Replace the battery.</p>
250	THERMIC SENS. KO	O	O	Cause: The output of the controller thermal sensor is out of range.	<p>Symptom: Maximum current is reduced according to parameter MOT.T. T.CUTBACK and speed is reduced to a fixed value.</p> <p>Troubleshooting: This kind of fault is not related to external components. Replace the controller.</p>
218	SENS MOT TEMP KO	O	O	Cause: The output of the motor thermal sensor is out of range.	<p>Symptom: Maximum current is reduced according to parameter MOT.T. T.CUTBACK and speed is reduced to a fixed value.</p> <p>Troubleshooting: Check if the resistance of the sensor is what expected measuring its resistance. Check the wiring. If the problem is not solved, replace the logic board.</p>

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
249	CHECK UP NEEDED	O	O	Cause: This is a warning to point out that it is time for the programmed maintenance.	Symptom: Alarm CHECK UP NEEDED. Troubleshooting: Turn on the CHECK UP DONE option after that the maintenance service.
248	NO CAN MSG	O	O	Cause: CAN-bus communication does not work properly. The hexadecimal value "XX" identifies the faulty node.	Symptom : MC is opened, EB is applied, Traction/Pump, valves stopped. Troubleshooting : Verify the CAN-bus network (external issue). Replace the logic board (internal issue).
247	DATA ACQUISITION	O	O	Cause: Controller in calibration state.	Symptom: Traction is stopped. Troubleshooting: The alarm ends when the acquisition is done.
246	EB. DRIV.OPEN	O	O	Cause: The EB driver is not able to drive the load. The device itself or its driving circuit is damaged.	Symptom: MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped. Troubleshooting : This type of fault is not related to external components. Replace the logic board.
237	ANALOG INPUT	O	O	Cause: This alarm occurs when the A/D conversion of the analog inputs returns frozen values, on all the converted signals, for more than 400 ms. The goal of this diagnosis is to detect a failure in the A/D converter or a problem in the code flow that skips the refresh of the analog signal conversion.	Symptom: MC is opened, EB is applied, traction/pump stopped. Troubleshooting: If the problem occurs permanently it is necessary to replace the logic board.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
8	WATCHDOG	O	O	Cause: This is a safety related test. It is a self-diagnosis test that involves the logic between master and supervisor microcontrollers.	Symptom : MC is opened, EB is applied, Traction/Pump, valves stopped. Troubleshooting : This alarm could be caused by a CAN bus malfunctioning, which blinds master-supervisor communication.
204	BRAKE RUN OUT	O	O	Cause: The CPOT BRAKE input read by the microcontroller is out of the range defined by parameters SET PBRK. MIN and SET PBRK. MAX (ADJUSTMENTS list, paragraph 8.2.3).	Symptom: Traction is stopped. Troubleshooting : Check the mechanical calibration and the functionality of the brake potentiometer. Acquire the minimum and maximum potentiometer values. If the alarm is still present, replace the logic board.
233	POWERMOS SHORTED	O	O	Cause: The DC-link voltage drops to zero when a high-side or low-side MOSFET is turned on.	Symptom: MC is opened, EB is applied, traction/pump stopped. Troubleshooting: Check that motor phases are correctly connected. Check that there is no dispersion to ground for every motor phase. In case the problem is not solved, replace the controller.
37	CONTACTOR CLOSED	O		Cause: Before driving the LC coil, the controller checks if the contactor is stuck. The controller drives the power bridge for several dozens of milliseconds, trying to discharge the capacitors bank. If the capacitor voltage does not decrease by more than a certain percentage of the key voltage, the alarm is raised.	Symptom: MC is not closed (command is not activated), EB is applied, Traction/Pump stopped. Troubleshooting: It is suggested to verify the power contacts of LC: if they are stuck, is necessary to replace the LC.
123	AUTOBALANCE FUNC	O		Cause: AUTO_BALANCE FUNCTION can be activated only when no direction switch is closed. The controller should alarm if the AUTO_BALANCE FUNCTION is activated when the direction switch is closed.	Symptom: The controller does not perform this function. Troubleshooting: Reset the AUTOBALANCE switch.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
228	TILLER OPEN	0		Cause: Tiller/seat input has been inactive for more than 120 seconds.	Symptom: LC opens. Troubleshooting: Activate the tiller/seat input. Check the tiller/seat input state through the TESTER function. Check the wirings. Check if there are failures in the microswitches. If the problem is not solved, replace the logic board.
232	CONT. DRV. EV	0	0	Cause: One or more on/off valve drivers are not able to drive the load. For the meaning of code "XX", refer to paragraph 0.	Symptom: Valves stopped. Troubleshooting: The device or its driving circuit is damaged. Replace the controller.
234	DRV. SHOR. EV	0	0	Cause: One or more on/off valve drivers are shorted. For the meaning of code "XX", refer to paragraph 0.	Symptom: Valves stopped. Troubleshooting: Check if there is a short circuit or a low impedance path between the negative terminals of the involved coils and -B. If the problem is not solved, replace the logic board.
217	PEV NOT OK	0	0	Cause: Terminal PEV (pin A3) is not connected to the battery or the voltage is different from that defined by parameter SET POSITIVE PEB. This alarm can occur if one output among EVP, EV1, EV2, EV3, HORN is present or AUX OUT FUNCTION is active.	Symptom: Pump motor stopped, valves stopped. Troubleshooting: Check PEV terminal (pin A3): it must be connected to the battery voltage (after the main contactor). Set the nominal PEV voltage in parameter SET POSITIVE PEB in the ADJUSTMENTS list.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
220	VKEY OFF SHORTED	0	0	Cause: At key-on, the logic board measures a voltage value of the KEY input that is constantly out of range, below the minimum allowed value.	Symptom: MC is not closed, EB is applied, Traction/Pump stopped. Troubleshooting: Check that the battery has the same nominal voltage of the inverter. Check the battery voltage, if it is out of range replace the battery. If the battery voltage is ok, replace the logic board.
211	STALL ROTOR	0	0	Cause: The traction rotor is stuck or the encoder signal is not correctly received by the controller.	Symptom: Traction/Pump stopped. Troubleshooting: Check the encoder condition. Check the wiring. Through the TESTER function, check if the sign of FREQUENCY and ENCODER are the same and if they are different from zero during a traction request. If the problem is not solved, replace the logic board.
240	EVP DRIVER OPEN	0	0	Cause: The EVP driver (output NEVP, pin A23) is not able to drive the EVP coil. The device itself or its driving circuit is damaged.	Symptom: MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped. Troubleshooting: This fault is not related to external components. Replace the logic board.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting										
202	VDC LINK OVERV.	O	O	<p>Cause: This fault is displayed when the controller detects an overvoltage condition. Overvoltage threshold depends on the nominal voltage of the controller.</p> <table border="1"> <tr> <td>Nominal voltage</td> <td>24 V</td> <td>36 V, 48 V</td> <td>80 V</td> <td>96 V</td> </tr> <tr> <td>Overvoltage threshold</td> <td>35 V</td> <td>72.5 V</td> <td>115 V</td> <td>125 V</td> </tr> </table> <p>As soon as the fault occurs, power bridge and MC are opened. The condition is triggered using the same HW interrupt used for under-voltage detection, microcontroller discerns between the two evaluating the voltage present across DC-link capacitors: High voltage → Overvoltage condition Low/normal voltage → Under-voltage condition</p>	Nominal voltage	24 V	36 V, 48 V	80 V	96 V	Overvoltage threshold	35 V	72.5 V	115 V	125 V	<p>Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped.</p> <p>Troubleshooting: If the alarm happens during the brake release, check the line contactor contact and the battery power-cable connection.</p>
Nominal voltage	24 V	36 V, 48 V	80 V	96 V											
Overvoltage threshold	35 V	72.5 V	115 V	125 V											
236	CURRENT GAIN	O	O	<p>Cause: The current gain parameters are at the default values, which means that the maximum current adjustment procedure has not been carried out yet.</p>	<p>Symptom: Controller works, but with low maximum current.</p> <p>Troubleshooting: Ask for assistance to a Zapi technician in order to do the adjustment procedure of the current gain parameters.</p>										
241	COIL SHOR. EVAUX	O	O	<p>Cause: This alarm occurs when there is an overload on any of the auxiliary voltage controlled outputs: NEV1 A25, NEV2 A34 and NEV3 A35.</p>	<p>Symptom: MC is opened, EB is applied, Traction/Pump, valves stopped.</p> <p>Troubleshooting: The typical root cause is in the wiring harness or in the load coil. Check the connections between the controller output and the load.</p>										

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
242	OPEN COIL EV.	O	O	Cause: This fault appears when no load is connected between one or more EV outputs and the positive terminal PEV (pin A3). For the meaning of code "XX", refer to paragraph 0.	Symptom: MC remains closed, EB is applied, Traction/Pump, valves stopped (the command is released). Troubleshooting: Check the coils. Check the wiring. If the problem is not solved, replace the logic board.
216	EB. COIL OPEN	O	O	Cause: No load is connected between the NEB output (pin A28) and the EB positive terminal PEB (pin A27).	Symptom: MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped. Troubleshooting: Check the EB coil. Check the wiring. If the problem is not solved, replace the logic board.
230	LC COIL OPEN	O		Cause: No load is connected between the NLC output (pin A12) and the positive voltage (for example +KEY).	Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Check the wiring, in order to verify if LC coil is connected to the right connector pin and if it is not interrupted. If the alarm is still present, rather than the problem is inside the logic board: replace it.
224	WAITING FOR NODE	O	O	Cause: The controller receives from the CAN bus the message that another controller in the net is in fault condition; as a consequence, the controller itself cannot enter into an operative status, but it has to wait until the other node comes out from the fault status.	Symptom: MC is opened, EB is applied, Traction/Pump stopped. Troubleshooting: Check if any other device on the CAN bus is in fault condition.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
253	FIELD ORIENT. KO	O	O	Cause: The error between the estimated Id (d-axis current) and the relative setpoint is out of range.	Symptom : MC is opened, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Ask for assistance to a Zapi technician in order to do the correct adjustment of the motor parameters.
245	IQ MISMATCHED	O	O	Cause: The error between the estimated Iq (q-axis current) and the related set point is out of range.	Symptom: Traction is stopped. Troubleshooting: Ask for assistance to a Zapi technician in order to do the correct adjustment of the motor parameters.
180	OVERLOAD	O	O	Cause: The motor current has overcome the limit fixed by hardware.	Symptom: MC is not closed, EB is applied, Traction/Pump stopped. Troubleshooting : If the alarm condition occurs again, ask for assistance to a Zapi technician. The fault condition could be affected by wrong adjustments of motor parameters.
200	VDC OFF SHORTED	O	O	Cause: The logic board measures a voltage value across the DC-link that is constantly out of range, above the maximum allowed value.	Symptom: VDC OFF SHORTED. Troubleshooting : Check that the battery has the same nominal voltage of the inverter. Check the battery voltage, if it is out of range replace the battery. If the battery voltage is ok, replace the logic board.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
179	STEER SENSOR KO	O	O	Cause: The voltage read by the microcontroller at the steering-sensor input is not within the STEER RIGHT VOLT ÷ STEER LEFT VOLT range, programmed through the STEER ACQUIRING function.	Symptom: Speed is reduced according to parameter CTB. STEER ALARM. Troubleshooting: Acquire the maximum and minimum values coming from the steering potentiometer through the STEER ACQUIRING function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. If the problem is not solved, replace the logic board.
196	MOT.PHASE SH.	O	O	Cause: Short circuit between two motor phases. The hexadecimal value "XX" identifies the shorted phases: 36: U - V short circuit 37: U - W short circuit 38: V - W short circuit.	Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Verify the motor phases connection on the motor side. Verify the motor phases connection on the inverter side. Check the motor power cables. Replace the controller. If the alarm does not disappear, the problem is in the motor. Replace it.
205	EPS RELAY OPEN	O	O	Cause: The controller receives from EPS information about the safety contacts being open.	Symptom: Traction/Pump motor is stopped. Troubleshooting: Verify the EPS functionality.
239	CONTROLLER MISM.	O	O	Cause: The software is not compatible with the hardware. Each controller produced is "signed" at the end of line test with a specific code mark saved in EEPROM according to the customized part number. According with this "sign", only the customized firmware can be uploaded.	Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Upload the correct firmware. Ask for assistance to a Zapi technician in order to verify that the firmware is correct.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
214	EVP COIL OPEN	O	O	Cause: No load is connected between the NEVP output (pin A23) and the electrovalve positive terminal.	Symptom: Valves stopped. Troubleshooting: Check the EVP condition. Check the EVP wiring. If the problem is not solved, replace the logic board.
215	EVP DRIV. SHORT.	O	O	Cause: The EVP driver (output NEVP, pin A23) is shorted. The microcontroller detects a mismatch between the valve set-point and the feedback of the EVP output.	Symptom: MC is opened, EB is applied, EVP stopped. Troubleshooting: Check if there is a short circuit or a low-impedance conduction path between the negative of the coil and -B. Collect information about: the voltage applied across the EVP coil, the current in the coil, features of the coil. Ask for assistance to Zapi in order to verify that the software diagnoses are in accordance with the type of coil employed. If the problem is not solved, it could be necessary to replace the controller.
229	HW FAULT EB.	O	O	Cause: At start-up, the hardware circuit dedicated to enable and disable the EB driver (output NEB, pin A28) is found to be faulty. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem.	Symptom: MC is opened, EB is applied, Traction/Pump stopped. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
227	HW FAULT	O	O	Cause: At start-up, some hardware circuit intended to enable and disable the power bridge or the LC driver (output NLC, pin A12) is found to be faulty. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem.	Symptom: MC is not closed, EB is applied, Traction/Pump stopped. Troubleshooting: This type of fault is related to internal components. Replace the logic board.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
176	EVP COIL SHORT.	O	O	Cause: On output NEVP A29, is shorted to ground. The microcontroller detects a mismatch between the valve set-point and the feedback of the EVP output.	Symptom: Valves stopped. Troubleshooting: Check if there is a short circuit or a low-impedance conduction path between the negative of the coil and -B.
210	WRONG RAM MEM.	O	O	Cause: The algorithm implemented to check the main RAM registers finds wrong contents: the register is "dirty". This alarm inhibits the machine operations.	Symptom : MC is opened, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Try to switch the key off and then on again, if the alarm is still present replace the logic board.
208	EEPROM KO	O	O	Cause: A HW or SW defect of the non-volatile embedded memory storing the controller parameters. This alarm does not inhibit the machine operations, but it makes the truck to work with the default values.	Symptom: Controller works using default parameters. Troubleshooting: Execute a CLEAR EEPROM procedure (refer to the Console manual). Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will be replaced by the default parameters.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
223	COIL SHOR. MC	O		Cause: This alarm occurs when there is an overload of the MC driver (pin A26) or EB driver (pin A28). As soon as the overload condition disappears, the alarm will be removed automatically by releasing and then enabling a travel demand.	Symptom : MC is opened, EB is applied, Traction/Pump, valves stopped. Troubleshooting: The typical root cause is in the wiring harness or in the load coil. So, the very first check to carry out concerns the connections between the controller outputs and the loads. Collect information about characteristics of the coils connected to the two drivers and ask for assistance to a Zapi technician in order to verify that the maximum current that can be supplied by the hardware is not exceeded.
207	INIT VMN LOW	O	O	Cause: Before closing the LC, the software checks the power bridge voltage without driving it. The software expects the voltage to be in a “steady state” value. If it is too low, this alarm occurs. The hexadecimal value “XX” identifies the faulty phase: 01: phase U 02: phase V 03: phase W.	Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting : Check the motor power cables. Check the impedance between U, V and W terminals and -B terminal of the controller. Check the motor leakage to truck frame. If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller. Replace it.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
206	INIT VMN HIGH	O	O	Cause: Before closing the LC, the software checks the power bridge voltage without driving it. The software expects the voltage to be in a "steady state" value. If it is too high, this alarm occurs. The hexadecimal value "XX" identifies the faulty phase: 81: phase U 82: phase V 83: phase W.	Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting : Check the motor power cables. Check the impedance between U, V and W terminals and -B terminal of the controller. Check the motor leakage to truck frame. If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller. Replace it.
213	POSITIVE LC OPEN	O		Cause: The voltage feedback of the LC driver (output NLC, pin A12) is different than expected.	Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Verify LC coil is properly connected. Verify CONF. POSITIVE LC parameter is set in accordance with the actual coil positive supply (see paragraph 8.2.5). Software makes a proper diagnosis depending on the parameter: a wrong setting could generate a false fault. In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
222	SEAT MISMATCH	O	O	Cause: This alarm can appear only in a traction + pump configuration or in a multi-motor one. There is an input mismatch between the traction controller and the pump controller relatively to the TILLER/SEAT input (A1): the two values recorded by the two controllers are different.	Symptom: MC is not closed, EB is applied, Traction/Pump stopped. Troubleshooting : Check if there are wrong connections in the external wiring. Using the TESTER function, verify that the seat inputs are in accordance with the actual state of the external switch. In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
201	CURRENT PROFILE	O	O	Cause: There is an error in the choice of the current profile parameters. Points P0 through P3 are expected to describe a descending profile.	Symptom: EB is applied, Traction/Pump motor is stopped. Troubleshooting: Check the values under the CURRENT PROFILE list.
197	WRONG SLAVE VER.	O	O	Cause: There is a mismatch in the software versions of master and supervisor microcontrollers.	Symptom: MC opened, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Upload the software to the correct version or ask for assistance to a Zapi technician.
198	M/S PAR CHK MISM	O	O	Cause: At start-up there is a mismatch in the parameter checksum between the master and the supervisor microcontrollers.	Symptom: MC stays closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Restore and save again the parameters list.
199	PARAM TRANSFER	O	O	Cause: Master uC is transferring parameters to the supervisor.	Symptom: MC stays closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Wait until the end of the procedure. If the alarm remains longer, re-cycle the key.
238	HW FAULT EV.	O	O	Cause: At start-up, the hardware circuit dedicated to enable and disable the EV drivers is found to be faulty. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem.	Symptom: MC is not closed, EB is applied, Traction/Pump stopped. Troubleshooting: This type of fault is not related to external components. Replace the logic board.
212	POWER MISMATCH	O	O	Cause: The error between the power setpoint and the estimated power is out of range.	Symptom: Traction is stopped, EB is applied, MC is opened. Troubleshooting: Ask for assistance to a Zapi technician about the correct adjustment of the motor parameters.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
193	SMARTDRIVER KO	0	0	Cause: Hardware problem in the circuit for the management of smart driver. The driver is turned ON but the output voltage does not increase.	<p>Symptom: MC is not closed, Traction/Pump, valves stopped.</p> <p>Troubleshooting: Verify that the coil is connected correctly between terminals PEB (pin A27) and NEB (pin A28). The output of Smart driver is in fact evaluated checking the voltage feedback of low side driver. Verify that the parameter POSITIVE EB is set in accordance with the actual coil positive supply. The software makes a proper diagnosis depending on the parameter: a wrong setting could generate a false fault. In case no failures/problems have been found, the problem is in the controller, which has to be replaced.</p>
194	AUX BATT. SHORT.	0	0	Cause: The voltage on PEB output (pin A27) is at high value even if it should not. For the versions where the smart driver is not installed (36/48V), it is possible to decide where the positive supply for pin A27 comes from by choosing a dedicated hardware configuration. The parameter POSITIVE E.B. has to be set in accordance with the hardware configuration (see paragraph 8.2.5), because the software makes a proper diagnosis depending on the parameter: a wrong setting could generate a false fault. The available choices are: 0 = PEB is managed by the smart driver (available for 24V version only). 1 = PEB comes from the TILLER input (A1). 2 = PEB comes from PAUX (A3). PAUX must be connected to terminal +B of the controller. This is the default configuration for 36/48V and 80V version. This alarm can only appear if POSITIVE E.B. is set as 1 TILLER/SEAT.	<p>Symptom: None</p> <p>Troubleshooting: Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply (see paragraph 8.2.5). In case no failures/problems have been found, the problem is in the controller, which has to be replaced.</p>

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
195	POS. EB. SHORTED	0	0	Cause: The voltage on terminal PEB (pin A27) is at the high value even if the smart driver is turned OFF.	<p>Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped.</p> <p>Troubleshooting: Verify that the parameter POSITIVE EB is set in accordance with the actual coil positive supply (see paragraph 8.2.5). Since the software makes a proper diagnosis depending on the parameter, a wrong setting could generate a false fault. Check if there is a short or a low impedance path between PEB (pin A27) and the positive battery terminal +B. In case no failures/problems can be found, the problem is in the controller, which has to be replaced.</p>
178	MOTOR TEMP. STOP	0	0	Cause: The temperature sensor has overtaken the threshold defined by STOP MOTOR TEMP.	<p>Symptom: EB is applied, Traction/Pump, valves stopped.</p> <p>Troubleshooting:</p> <ul style="list-style-type: none"> - Check the temperature read by the thermal sensor inside the motor through the MOTOR TEMPERATURE reading in the TESTER function. - Check the sensor ohmic value and the sensor wiring. - If the sensor is OK, improve the cooling of the motor. - If the warning is present when the motor is cool, replace the controller.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
177	COIL SHOR. EB.	O	O	Cause: This alarm occurs when an overload of the EB driver (output NEB A18) occurs.	<p>Symptom: MC is opened, EB is applied, Traction/Pump, valves stopped</p> <p>Troubleshooting:</p> <ul style="list-style-type: none"> - Check the connections between the controller outputs and the loads. - Collect information about characteristics of the coil connected to the driver and ask for assistance to a Zapi technician in order to verify that the maximum current that can be supplied by the hardware is not exceeded. - In case no failures/problems have been found, the problem is in the controller, which has to be replaced.
185	TILLER ERROR	O	O	Cause: Input mismatch between H&S input (pin A6) and TILLER/SEAT input (pin A1): the two inputs are activated at the same time.	<p>Symptom: Traction stopped, EB applied.</p> <p>Troubleshooting: Check if there are wrong connections in the external wiring. Using the TESTER function of the controller verify that the input-related readings are in accordance with the actual state of the external input switches. Check if there is a short circuit between pins A6 and A1 in case no failures/problems have been found, the problem is in the controller, which has to be replaced.</p>

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
186	WAIT MOT.P STILL	0	0	Cause: The controller is waiting for the motor to stop rotating. This warning can only appear in BLE2 NEW GENERATION for brushless motors.	Symptom: MC is not closed, EB is applied, Traction/Pump stopped. Troubleshooting: The controller receives from the CAN bus the message that another controller in the net is in fault condition; as a consequence, the controller itself cannot enter into an operative status, but it has to wait until the other node comes out from the fault status.
175	SPEED OVERHEAD	0	0	Cause: The motor speed has exceeded the maximum defined by parameter TOP MAX SPEED (under HARDWARE SETTINGS) by more than a 100 Hz excess.	Symptom: MC is opened, EB is applied, Traction/Pump stopped. Troubleshooting: Check the motor parameters. Ask for assistance to a Zapi technician.
171	ACQUIRING A.S.	0	0	Cause: Controller is acquiring data from the absolute feedback sensor.	Symptom: None Troubleshooting: The alarm ends when the acquisition is done.
173	ACQUIRE END	0	0	Cause: Absolute feedback sensor acquired.	Symptom: None Troubleshooting: The alarm ends when the acquisition is done.
181	WRONG FBSENS.SET	0	0	Cause: Mismatch between parameters ENCODER PULSES 1 and ENCODER PULSES 2	Symptom: MC is not closed, EB applied, Traction/Pump, valves stopped. Troubleshooting: Set the two parameters with the same value, according to the adopted encoder.
172	ACQUIRE ABORT	0	0	Cause: The acquiring procedure relative to the absolute feedback sensor aborted.	Symptom: None Troubleshooting: The alarm ends when the acquisition is done.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
168	SPEED FB.ERR. XX	O	O	Cause: Motor speed encoder feedback problem.	Symptom: MC is opened, EB is applied, EVP stopped. Troubleshooting: Test the connection of motor encoder.
159	HVIL FAIL	O	O	Cause: The low voltage circuit detects that the high voltage components, conductors, and connectors are abnormal.	Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Check the status of high voltage components, conductors, and connectors.
162	POS.EB.SHORT PIN	O	O	Cause: The voltage on terminal PEB A27, downstream the internal smart diver and input PIN A24, is sensed higher than expected with the smart driver driven OFF.	Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply. Check if there is an external short or a low impedance path between PEB A27 and the positive battery terminal +B.
163	ED SLIP MISMATCH	O	O	Cause: The control detects a mismatch between the expected slip and the evaluated one. This diagnostic occurs only if ED COMPENSATION = TRUE.	Symptom: MC is opened, EB is applied, Traction/Pump stopped. Troubleshooting: Check the status of ED COMPENSATION parameter.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
164	POS.EB.SHORT GND	O	O	Cause: The voltage on terminal PEB A27, downstream the internal smart diver and input PIN A24, is sensed lower than expected after the smart driver is driven ON.	Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped. Troubleshooting: Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply Check if there is an external short or a low impedance path between PEB A27 and any ground reference (-B or GND).
161	RPM HIGH	O	O	Cause: This alarm occurs in Gen. Set versions when the speed exceeds the threshold speed.	Symptom: MC is opened, Traction/Pump stopped. Troubleshooting: This alarm can appear only in a traction + pump configuration or in a multi-motor one. There is an input mismatch between the traction controller and the pump controller relatively to the TILLER/SEAT input (A1): the two values recorded by the two controllers are different.
160	SENS BAT TEMP KO	O	O	Cause: The output of the motor thermal sensor is out of range.	Symptom: Maximum current is reduced according to parameter MOT.T. T.CUTBACK and speed is reduced to a fixed value. Troubleshooting: Check if the resistance of the sensor is what expected measuring its resistance. Check the wiring.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
170	WRONG KEY VOLT.	O	O	Cause: The measured key voltage is not within the range defined by parameters SET BATTERY, VOLTAGE THR LOW and VOLTAGE THR HIGH under SET OPTIONS.	<p>Symptom: MC is not closed, EB is applied, Traction/Pump, valves stopped.</p> <p>Troubleshooting: Check the settings of parameters SET BATTERY, VOLTAGE THR LOW and VOLTAGE THR HIGH under SET OPTIONS to be in accordance with the battery in use. Adjust the SET KEY VOLTAGE calibration under ADJUSTMENTS: tune it to be in accordance with the actual key voltage. Check if the key voltage is ok using a voltmeter, if not check the wiring. In case the problem is not solved, replace the logic board.</p>
158	NOT RDY DRV.POW.	O	O	Cause: The error between the power setpoint and the estimated power is out of range.	<p>Symptom: Traction is stopped, EB is applied, MC is opened.</p> <p>Troubleshooting: Ask for assistance to a Zapi technician about the correct adjustment of the motor parameters.</p>
157	FAULT DRV.POWER	O	O	Cause: The error between the power setpoint and the estimated power is out of range.	<p>Symptom: Traction is stopped, EB is applied, MC is opened.</p> <p>Troubleshooting: Ask for assistance to a Zapi technician about the correct adjustment of the motor parameters.</p>
155	WAIT MOTOR STILL	O	O	Cause: The controller is waiting for the motor to stop rotating. This warning can only appear in BLE2 NEW GENERATION for brushless motors.	<p>Symptom: MC is not closed, EB is applied, Traction/Pump stopped</p> <p>Troubleshooting: The controller receives from the CAN bus the message that another controller in the net is in fault condition: as a consequence, the controller itself cannot enter into an operative status, but it has to wait until the other node comes out from the fault status.</p>

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
169	EMERGENCY	0	0	Cause: This alarm occurs when parameter EMERGENCY INPUT is set to 1 and the emergency input is active.	<p>Symptom: MC is opened, EB is applied, traction/pump and valves are disabled.</p> <p>Troubleshooting: The emergency input has been activated. Wait until the emergency conditions cease and restore the emergency input.</p>
153	OFFSET SPD.SENS.	0	0	Cause: It is necessary to acquire the offset angle between the stator and the speed sensor, i.e. they mutual angular misalignment. An automatic function is dedicated to this procedure.	<p>Symptom: EB is applied, Traction/Pump, valves stopped.</p> <p>Troubleshooting: Perform the teaching procedure.</p>
152	SENSOR SUPPLY XX	0	0	<p>Cause: The current supplied on pin PENC A10 (A8) or PPOT A4 (A2) is outside the range MIN.CURR.SUPPLY 1/2 through 200 mA. The hexadecimal value "XX" defines the following cases:</p> <p>01: PENC A10 (A8) below MIN.CURR.SUPPLY 1. 02: PENC A10 (A8) above 200 mA. 11: PPOT A4 (A2) below MIN.CURR.SUPPLY 2. 12: PPOT A4 (A2) above 200 mA.</p>	<p>Symptom: MC is opened, EB is applied, traction/pump and valves are disabled.</p> <p>Troubleshooting : If an undercurrent is detected, check that parameters MIN.CURR.SUPPLY 1 and MIN.CURR.SUPPLY 2 are appropriate for the device(s) connected to the faulty pin. Try to decrease them, even down to 0 mA. Check if the resistance of the load connected to the faulty pin is what expected measuring its resistance. Check the wiring. If an overcurrent is detected, try to disconnect the device(s) from the faulty pin. if the alarm persists, replace the logic board; if not, replace the device(s) connected to the faulty pin. If the problem is not solved, replace the logic board.</p>

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
203	HW FAULT MC	O	O	Cause: At start-up, some hardware circuit intended to enable and disable the power bridge or the LC driver on output NLC A26 (A16) is found to be faulty. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem.	Symptom: MC is not closed, EB is applied, Traction/Pump and valves are disabled. Troubleshooting: This type of fault is related to internal components. Replace the logic board.
151	POT MISMATCH	O	O	Cause: This alarm can occur only if the auxiliary potentiometer is of crossed-twin type, in combination with the main potentiometer. The sum of main and auxiliary potentiometers is not constant.	Symptom: Traction/Pump motor is disabled. Troubleshooting: Verify that the main and auxiliary potentiometers are properly connected. Check the mechanical and electrical functionality of the main and auxiliary potentiometers. Perform the acquisition of the potentiometers; ask for assistance to a Zapi technician if necessary. If the problem is not solved, replace the logic board.
154	AGV	O	O	Cause: The automatic guide is enabled and the periodic automatic-guide-request CAN message is missed.	Symptom: Traction is disabled. Troubleshooting: Check the CAN bus communication. Verify that the controller receives the periodic automatic-guide-request message. If necessary, ask for assistance to a Zapi technician in order to record and verify the CAN traces.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
150	NO CAN MSG DISP	O	O	Cause: CAN bus communication with the display does not work properly. Upon this alarm, economy mode is activated by default.	Symptom: CAN bus communication with the display does not work properly. Troubleshooting : Verify the CAN bus network and the display connected to it. By a multimeter check the impedance between CANH and CANL; it shall be 60 Ω . If the alarm persists, replace the logic board.
149	WRONG PERFORM.	O	O	Cause: This alarm occurs only if the PERFORMANCE parameter under SET OPTIONS is set to ON. The three performance levels (economy, normal, power) are not set in an ascending order of performance.	Symptom: Traction is disabled. Troubleshooting : Check the performance settings under the PERFORM. ECONOMY and PERFORM. POWER lists. The performance related parameters must be set in such a way that the economy mode results in the weakest and the power mode results the highest. Contact a Zapi technician for assistance.
148	BMS NOT READY	O		Cause: This alarm occurs if the BMS FUNCTION is enabled and the controller does not receive any information about the battery state of charge: the battery management system is not operative.	Symptom: MC is opened, EB is applied, traction/pump and valves are disabled. Troubleshooting : Check the battery charge and the battery management system status. Check the CAN bus communication.
147	17A0X	O	O	Cause: The lithium battery is faulty.	Symptom: Limited traction and oil pump function. Traction/Pump stopped. Troubleshooting: Check the lithium battery.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
146	SAFETY DIAG. XX	O	O	Cause: One of the safety related diagnosis has failed.	Symptom: MC is opened, EB is applied, Traction/Pump is disabled. Troubleshooting : The fault condition could be due to wrong adjustments of the safety related parameters.
145	SAFETY SW. XX	O	O	Cause: One of the safety related modules has reported an error.	Symptom: MC is opened, EB is applied, Traction/Pump is disabled. Troubleshooting : The fault condition could be due to wrong adjustments of the safety related parameters.
144	SAFETY WARN. XX	O	O	Cause:One of the safety related modules has reported an error.	Symptom: MC is opened, EB is applied, Traction/Pump is disabled. Troubleshooting : The fault condition could be due to wrong adjustments of the safety related parameters.
143	SAFETY INIT. XX	O	O	Cause: One of the safety related modules has reported an error during its initialization.	Symptom: MC is not closed, EB is applied, Traction/Pump is disabled. Troubleshooting : The fault condition could be due to wrong adjustments of the safety related parameters.
142	STO-SS1 ALARM XX	O	O	Cause: One between the STO and the SS1 procedures has reported an alarm. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem.	Symptom: MC is opened, EB is applied, Traction/Pump is disabled. Troubleshooting: The fault condition could be due to a timeout of the STO or SS1 procedure; the braking took too long. Check if the truck follows the imposed braking ramp and ask for assistance to a Zapi technician. In case the problem is not solved, replace the logic board.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
141	STO-SS1 ACTIVEXX	0	0	Cause: One between the STO and the SS1 procedures is in progress. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem.	Symptom: A warning is shown in the display. Troubleshooting: Wait until the STO procedure or SS1 procedure or both are done.
139	THERM.PU.SENS.	0	0	Cause: The output of the controller thermal sensor is out of range.	Symptom: Maximum current is reduced according to parameter MOT.T. T.CUTBACK and speed is reduced to a fixed value. Troubleshooting: This kind of fault is not related to external components. Replace the controller.
138	BACK EMF HIGH	0	0	Cause: The reverse electromotive force generated by the truck when braking is too high.	Symptom: MC is not closed, EB is applied, Traction/Pump stopped. Troubleshooting: Contact ZAPI to adjust the parameters.
137	SLAVE MOT ALARM	0	0	Cause: The master and supervisor microcontrollers detect the motor state differently.	Symptom: MC is not closed, EB is applied, Traction/Pump stopped. Troubleshooting: Connect the Console to the supervisor microcontroller and check which alarm is present.
136	DISPLAY ENABLE	0	0	Cause: the display enable signal has not been received to operate the truck.	Symptom: Traction/Pump stopped. Troubleshooting: To remove warning cause.
124	HW WRONG	0	0	Cause: The controller hardware is faulty.	Symptom: Disable all functions of the controller. Troubleshooting: Request ZAPI help or replace the controller.
134	BMS WARNING 0	0		Cause: The lithium battery is faulty.	Symptom: Traction/Pump stopped Troubleshooting: Check the lithium battery.

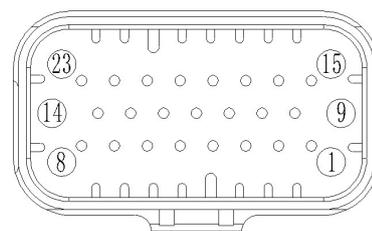
Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
133	BMS WARNING 1	O		Cause: The lithium battery is faulty.	Symptom: Traction/Pump stopped Troubleshooting: Check the lithium battery.
132	BMS WARNING 2	O		Cause: The lithium battery is faulty.	Symptom: Traction/Pump stopped Troubleshooting: Check the lithium battery.
131	OVERLOAD	O	O	Cause: The motor current has exceeded the hardware-fixed limit.	Symptom: MC is not closed, EB is applied, Traction/Pump stopped. Troubleshooting : If the alarm condition occurs again, ask for assistance to a Zapi technician. The fault condition could be affected by wrong adjustments of motor parameters.
130	LOAD SENS. ERROR	O	O	Cause: An error has occurred on the WEIGHING SENSOR.	Symptom: This function is disabled. Troubleshooting: Acquire the maximum and minimum potentiometer values through the ADJ MIN LOAD function.
129	FORK SENSOR LOCK	O	O	Cause: An error has occurred on the TILT ANGLE SENSOR.	Symptom: This function is disabled. Troubleshooting: Acquire the maximum and minimum potentiometer values through the TILT ANGLE 1 function.
128	FORK WRONG DIR.	O	O	Cause: TILT ANGLE SENSOR1 The maximum or minimum Angle is incorrect.	Symptom: This function is disabled. Troubleshooting: Acquire the maximum and minimum potentiometer values through the MAX/MIN ANGLE function.

Code	Alarm	Traveling	Pump	Causes	Symptom and troubleshooting
127	A17 INPUT ERROR	O		Cause: The BATTERY DOOR INHIBIT switch is turned on.	Symptom: Inhibit both traction and lift function. Troubleshooting: Close the BATTERY DOOR INHIBIT switch.
187	LIFT+LOWER		O	Cause: Both the pump requests (LIFT and LOWER) are active at the same time.	Symptom: Pump is stopped. Troubleshooting: Check that LIFT and LOWER requests are not active at the same time. Check the LIFT and LOWER states through the TESTER function. Check the wirings and the micro-switches. If the problem is not solved, replace the logic board.
135	A7 INPUT ERROR	O		Cause: The BATTERY CHARGE INHIBIT switch is turned on.	Symptom: Inhibit both traction and lift function. Troubleshooting: Close the BATTERY CHARGE INHIBIT switch.
126	SEAT BELT	O	O	Cause: The SEAT BELT switch is turned on.	Symptom: Traction speed is limited. Troubleshooting: Close the SEAT BELT switch.
125	ERR CONFIG BMS	O		Cause: A19 and A11 on PUMP only have one closed to -B.	Symptom: The controller cannot communicate with lithium. Troubleshooting: Check the A19 and A11 switches.
122	BATT SERIOUS LOW	O	O	Cause: The BATT SERIOUS LOW alarm occurs when the battery level is evaluated to be lower or equal to BATT LOW SER THRES of the full charge.	Symptom: Inhibit both track and lift functions. Troubleshooting: The battery is charged.

6. Cluster

1) Instrument interface definition

The combination instrument of DZB916~XDZG forklift adopts 23-core AMP776228 connector, and the docking end is compatible with Tyco Electronics AMP 770680-1. The definition of instrument interface is shown in below table.



Pin	Signal name	State	Remark
1	B+(normal fire)	DC18~100V	Connected to positive pole of battery pack
2	Negative pole of instrument power supply	/	Connected to negative pole of battery pack
3	DC+5V output	Power the load cell	Load less than 200mA
4	Load cell signal input	Voltage signal	0.5V~4.5V
5	Load cell ground wire	Instrument output	Common ground inside the instrument
6	Hand brake signal input	Switching value	Negative control
7	Seat switch	Switching value	Negative control
8	Switching value 2	Standby switching value 2	Control polarity can be set
9	Left turn signal input+	Switching value (isolated)	Positive control
10	CAN1_ H	CAN1 port (CAN Open, non isolated)	Matching resistor built-in
11	CAN1_ L		
12	CAN2_ H	CAN2 port (SAE J1939 (isolated))	Matching resistor built-in
13	CAN2_ L		
14	Switching value 4	Standby switching value 4	Control polarity can be set
15	PWM_ In	Connected to speed sensor	Standby speed signal
16	Right turn signal input+	Switching value (isolated)	Positive control
17	Brake fault signal input	Switching value	Negative control
18	Analog signal input 2	Standby analog quantity	Resistance signal
19	Analog signal input 3	Standby analog quantity	Voltage signal
20	DC-DC power supply negative terminal	/	Isolating ground
21	IGN+	Connected to ignition switch	Instrument power-on trigger signal
22	Switching value 3(isolated)	Standby switch(isolated)	Positive control
23	Switching value 13(isolated)	Standby switch(isolated)	Positive control

2) Basic technical indicators and requirements of instruments

① Working voltage

Instrument working voltage range: DC18V~100V;

② Working and storage temperature

Operating temperature range of the instrument: -30°C~75 °C;

Instrument storage temperature range: -40°C~85°C;

③ Communication interface

The instrument has two communication interfaces in accordance with CAN2.0B.

CAN1 port is standard frame CAN Open, baud rate is 125K bps, MOTOROLA data format. CAN2 port is an extended frame, the protocol is compatible with SAE J1939, the baud rate is 250K bps, Intel data format, with isolation.

④ ESD performance

Meet GB/T 19951-2005 (ISO10605:2001) standard contact discharge ±8KV, air discharge ±15KV, grade B or above.

⑤ Switching value

The input and output of instrument switch signal are shown in below table.

NO.	Function description	Icon	Colour	Normal working state	Alarm input status	remarks
1	Brake failure		red	CAN	CAN	
				Suspended	Low level	
2	Maintenance reminder		yellow	CAN	CAN	
3	High motor temperature		red	CAN	CAN	
4	Seat indication		yellow	CAN	CAN	
				Low level	Suspended	
5	Seat belt indication		red	CAN	CAN	
6	Parking indication		red	CAN	CAN	
				Low level	Suspended	
7	Low battery power		red	CAN, low battery alarm value can be set, 20% by default;		
8	slow mode		green	Press  to switch the tortoise speed mode and light up the symbol indication		
9	Gear R	R	red	CAN	CAN	Gear interlock
	Gear N	N	green	software control	software control	
	Gear F	F	blue	CAN	CAN	
10	High temperature of electric control system		red	CAN	CAN	
11	Operating mode H	H	white	Switch the working mode through  and light up the mode icon at the same time		Mode interlock
	Working mode N	N	white			
	Operating mode E	E	white			
12	Overload alarm indication		red	Software control, overload alarm value can be set, default is 110%.		
13	Lithium battery heating indication		green	CAN	CAN	

NO.	Function description	Icon	Colour	Normal working state	Alarm input status	remarks
14	Left turn indicator light		green	High potential	Suspended	
15	Right turn indicator light		green	High potential	Suspended	

3) Input and display requirements of function indicator

① Vehicle speed

Vehicle speed comes from CAN message. The vehicle speed of the instrument is displayed by analog pointer + digital display, unit: km/h; Range: 0~30km/h; Display accuracy: 0.1km/h.

② Working hours

The working hours are displayed digitally. Unit: h; Range: 0~99999.9h; Display accuracy: 0.1h.
Input signal: accumulated working hours will start when the instrument is powered on;

③ Battery power SOC

Battery power comes from CAN message. The battery power meter is displayed by the segment meter + digital meter.

Unit: percentage of rated capacity, range: 0~100%, display accuracy: 1%.

④ Load weight

The output signal of the load sensor (pressure transmitter) is a voltage signal with a voltage range of DC0.5~4.5V. The load weight is collected and displayed by the instrument. The display form is digital display; Unit: kg; Range: 0~150% of rated load; Display accuracy: 1% of full scale. The system error of the load signal sampled by the instrument is $\pm 5\%$ of the rated load.

The instrument has overload alarm function, and the overload limit can be set through the instrument. The default overload limit is 110% of the rated load.

⑤ Wheel steering angle

Wheel steering angle is from CAN message.

The steering angle display mode is analog pointer display. Unit: °; Range: $\pm 90^\circ$; Display accuracy: 1° .

⑥ Gantry tilt angle

Gantry tilt angle is from CAN message.

The gantry tilt angle is displayed digitally. Unit: °; Range: $\pm 20^\circ$; Display accuracy: 1°

⑦ DC+5V output

The instrument outputs 1 circuit of 5V power supply to supply power to the load cell (pressure transmitter). The +5V power output has automatic protection functions for ground, positive pole of input power, overload, etc.

※ Note: the load capacity of the +5V power supply is not more than 200mA;

⑧ Protection grade of instrument enclosure

The protection grade of instrument enclosure is IP65.

⑨ Symbols

Alarm symbols

The instrument alarm symbols are shown in below table.

NO.	Function description	Icon	Colour	remarks
1	Brake failure		red	Sound when alarming
2	Maintenance reminder		yellow	Sound and text prompt when alarming
3	High motor temperature		red	Sound and text prompt when alarming
4	Seat indication		yellow	
5	Seat belt indication		red	
6	Parking indication		red	
7	Low battery power		red	Light on when $\leq 20\%$ Sound and text prompt when $\leq 10\%$
8	High temperature of electric control system		red	Sound and text prompt when alarming
9	Overload alarm indication		red	Sound when alarming

Speedometer

The speedometer shows the current speed of the forklift in km/h.
The vehicle speed signal is sampled by the controller.
The controller sends it to the instrument for display via CAN bus.



Percentage of electricity (SOC)

The electricity meter (SOC) displays the current percentage of remaining battery power.
The power is sampled by BMS controller.
The controller sends it to the instrument for display via CAN bus.



Wheel steering angle

The rear wheel steering angle signal comes from the controller.
The display range is -90 degrees to 0 degrees to 90 degrees.
The rear wheel angle function can be turned on or off by entering the [Rear wheel angle function] interface in the [Function setting] menu



4) Instrument menu

There are four buttons below the cluster to operate and set the cluster.

Menu/back:



- ① Press this button to enter menu interface from main working interface.
- ② Back to last level (While the cluster is not in main working interface).



Up: Move the select cursor up.



Down: Move the select cursor down.



Enter: Enter to next level.



① System status interface

After enter menu interface, select "system status" and press enter button.



② Running parameters interface

After enter menu interface, select "Running parameters" and press enter button.



When using lithium battery, 6, 7, 8, 9 will show data.



③ Display settings interface

After enter menu interface, select “display settings” and press enter button.

In the display setting interface, the brightness of the LCD screen, time and language can be set. There are three languages, Chinese, English and Korean.



④ Weight calibration interface

The load weight signal comes from the sensor, and directly connected to cluster. In order to improve the weighing accuracy, the weighing sensor will be calibrated in the process of truck debugging.

Calibration of weight sensor

- Enter fork weight
- Enter load weight
- Confirm parameter

After enter menu interface, select “Weight calibration” and press enter button to start calibrating of weight sensor.



⑤ Function settings

After enter menu interface, select “function setting” and press enter button.



OPS setting

After enter function setting interface, select "OPS setting" and press enter button.

This number means duration of alarm.

- ※ Alarm when: Parking system is not working and operator is not on the seat whatever power on or off.



Gantry Tilt Angle

This function is not currently implemented.



Weighing display (OPT)

After enter function setting interface, select "Weighing display" and press enter button.



Wheels Steering Angle

This function is not currently implemented.



Hourly meter management

After enter function setting interface, select "Hourly meter management" and press enter button.

It will be used after truck debugging in factory only. Then hourly meter works normally.

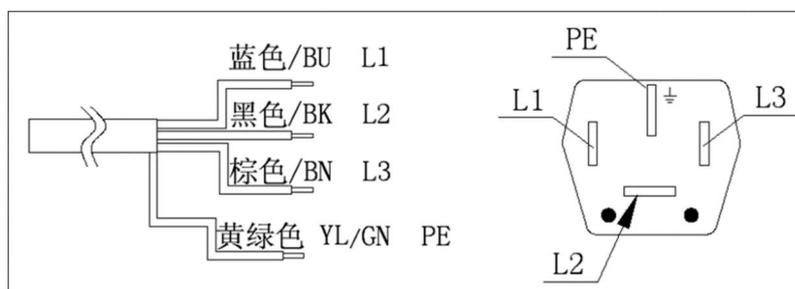
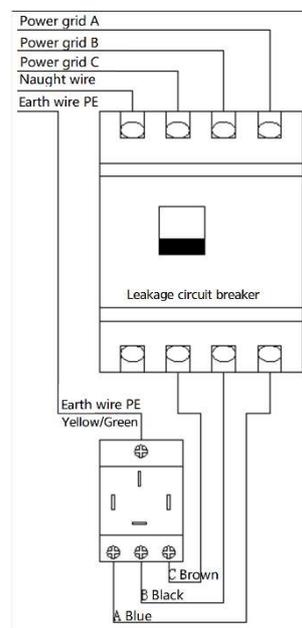
7. BATTERY CHARGER

This chapter explains basic information related to charger to help you easily understand and use it. This includes the contents from the way to install a charger to tips for emergency situations. This is focused on practices aiming to be usefully utilized in the field

1) Installation

The diameter of the AC input cable installed in single HWBC26 charger must be more than 4mm², and the power distribution circuit breaker capacity must be more than 25A. 4mm²*3C(A/B/C) +2.5mm²*1C(PE) 4-core copper cable is recommended.

- ▲ Only electricians who have received professional training and obtained working certificate can install this power system. Never violate the relevant safety regulations.
- ▲ The system voltage is 380VAC, which is a dangerous voltage. Insulation protection should be made during installation.
- ▲ Make sure the power system is not powered on if need to operate the power system inside the cabinet. The input of the power system and the battery must be disconnected.



2) Charge

Before using the charger, professionals must check:

- ① Whether the battery and the charger match.
 - ② Confirm that the battery is correctly connected to the charging machine.
 - ③ The ground cable must be grounded reliably.
 - ④ Open the liquid cover or seal cover.
 - ⑤ Do not smoke near the battery while charging.
 - ⑥ No fireworks in the vicinity while charging.
- ※ Do not charge different types of batteries in series or parallel.

Charge step:

- ① Connect to battery.
- ② Connect to power.
- ▲ Do not pull down the charging plug before closing the charger. Otherwise, an electric spark may cause a fire or even an explosion!



Charge state adjustment switch

- ① When the battery charging effect is poor, this switch could adjust the charging conditions.
- ② If battery runs low, adjust the switch to “0” or “II”, then battery capacity charged could be 5% or 10% more than in “I” charging state.
- ③ If the electrolyte is consumed too fast or battery temperature too high during charging, switch to “0” or “I” which means battery capacity charged could be 5% or 10% less than before.

Switch	I	0	II
coefficient	1.1	1.15	1.2



Charging mode

Off/On button:

- Pause the charging, then it can be disconnected.
- Restart the charging after connecting.

Information button:

- Press for 5 seconds to switch to BALANCE CHARGING, balance light will be on.
- Press for 10 seconds to switch to DESULFURIZATION CHARGING, desulf light will be on.
- Press for 15 seconds to switch to FIRST CHARGING, desulf light and balance light will be on.
- Press for 3 seconds to cancel last three charging mode.
- Press for 2 seconds to enter inquiring interface.



Pilot light and backlight

- Backlight is white when charging normally.
- Off/On: Green light will be on when charging normally. Red light will be on when charging paused and backlight will be yellow,
- Full: Full light will be on when charging has been finished and backlight will be green.
- Error: Backlight will be red and there will be a code in screen when there is an error.

BALANCE CHARGING

It means must to balance charging when in the flowing condition:

- Once a month in normal using.
- Battery is totally empty or discharge current is too big.
- The voltage of a single battery is less than 1.75V or less than 1.8V for more than three times after using.

In balance charging, test the electrolyte density of the battery every 1-2 hours until the electrolyte reached $1.280 \pm 0.005 \text{g/cm}^3 (25^\circ\text{C})$. If the density is higher than the specified value, add distilled water and continue to charge 0.5-1 hours, in order to make the electrolyte density uniform, Balance charging is end when density difference of each cell electrolyte is no more than 0.01g/cm^3 .

DESULFURIZATION CHARGING

Plate of the battery is vulcanized

- Capacity of battery decline obviously than normal
- Electrolyte gravity is lower than that of other batteries working at the same time, or much lower than normal
- The voltage rises quickly when charging, and drops quickly when discharging,

Causes of battery plate vulcanization

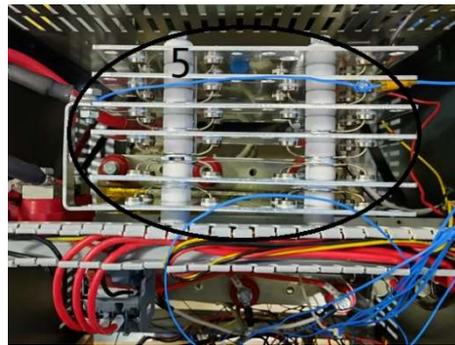
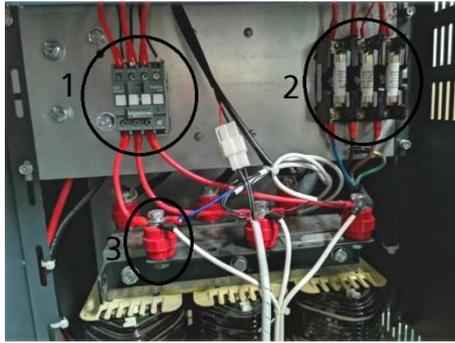
- Excessive discharge
- Lack of charging for a long time, or prolonged half discharge
- The level of electrolyte is too low
- The proportion of electrolyte is too large
- Battery has not been charged in time when it has been storage.

FIRST CHARGING

The accumulated amount of power charged into the battery, which should be 5~6 times the rated capacity of the battery, the voltage of each battery is above 2.7-2.75V, at this time, the electrolyte bubble. After the proportion of electrolyte is adjusted, the voltage does not rise for three hours, indicating that the battery is fully charged.

Batteries have been first charged before leaving the factory, and users no longer need to perform additional first charging.

3) Inner part



- | | | | | | |
|---|-----------------------|---|------------------------|---|------------|
| 1 | Three-phase contactor | 4 | Output fuse | 7 | Display |
| 2 | Input fuse | 5 | Plate rectifier bridge | 8 | Controller |
| 3 | Transformer | 6 | Slave transformer | | |

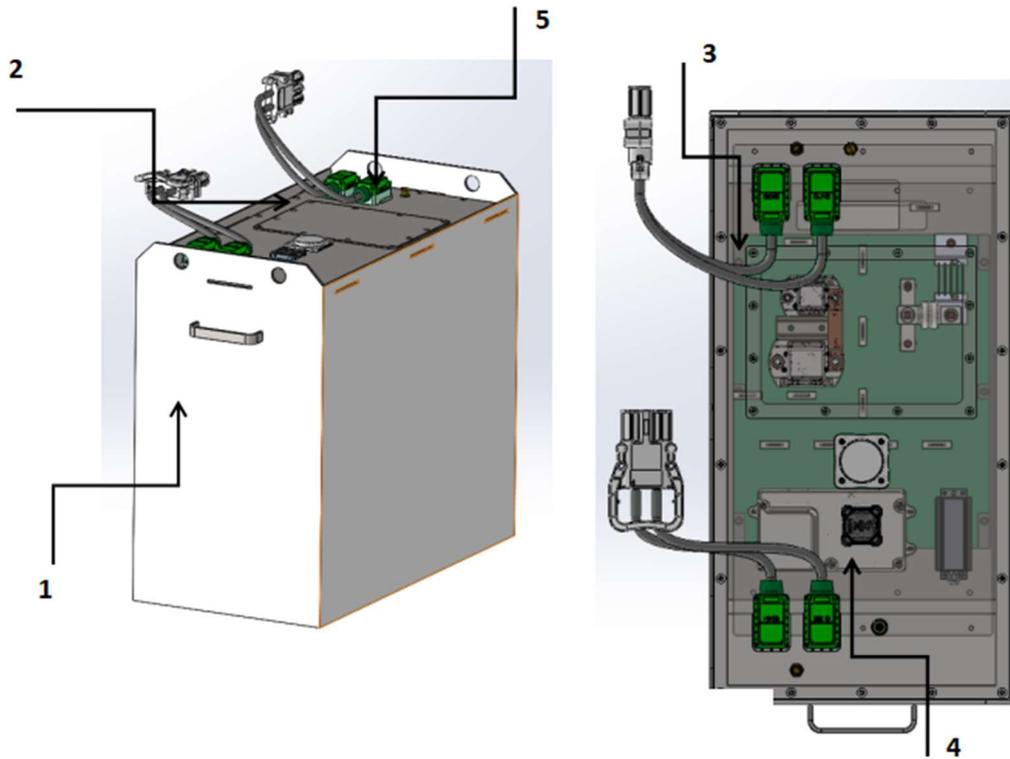
4) Troubleshooting

No.	Code	Reason	Troubleshooting
1	E-1	Battery is disconnecting	Connect to battery
2	E-2	Voltage of battery is too low or the battery does not match	Check
3	E-3	Charge error	Check controller of charge
4	E-4	Voltage of battery is too high or the battery does not match	Check
5	E-5	Voltage of battery is too high	Check controller of charge and battery
6	E-6	Input phase loss protection	Check input fuse
7	E-9	The charger output overcurrent	Check controller of charge and battery
8	E-10	The rectifier bridge of the charger is overheating	Check the radiator of the charger and rectifier bridge
9	E-11	The charger transformer is overheating	Check the radiator of the charger and transformer
10	E-15	The charger input undervoltage	Check input voltage
11	E-16	The charger input overvoltage	Check input voltage
12	F-21	Battery is shedding while charging	Check output fuse

8. Lithium Battery (OPT)

1) STRUCTURE

① Battery pack



1 Housing

3 Module

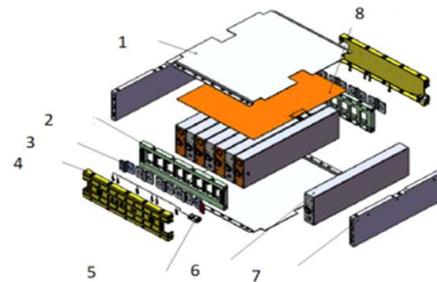
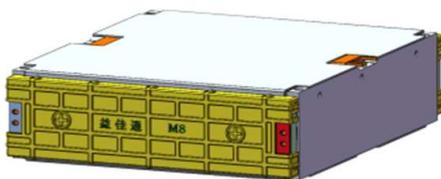
5 Cable

2 Top case

4 BMS

② Battery module

2 Wiring busbar



1 Aluminum cover plate

4 Plastic cover

7 End plate

2 Wire harness bracket

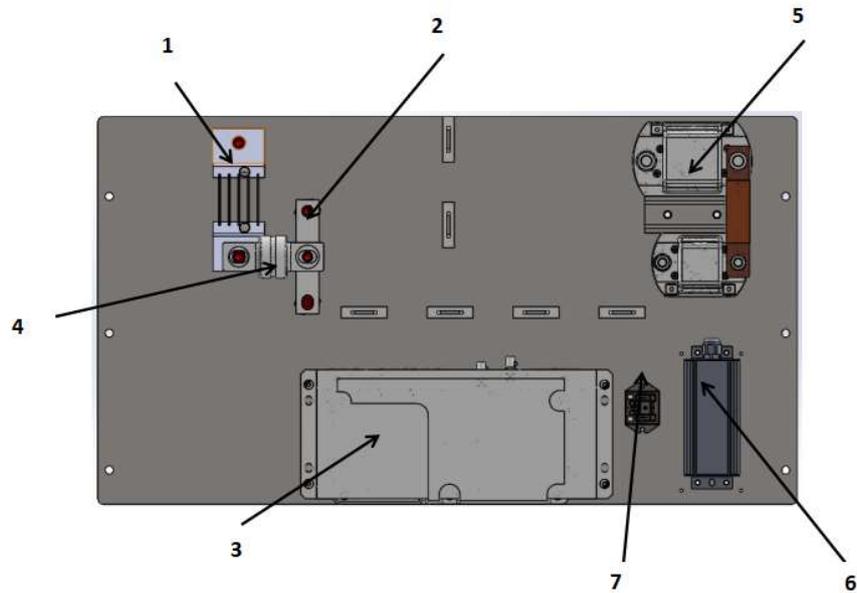
5 Acquisition harness

8 Heating plate

3 Tandem array

6 Electric core

③ Electrical board



- | | | |
|-----------------|---------|---------|
| 1 Diverter | 4 Fuse | 6 DC-DC |
| 2 Wiring busbar | 5 Relay | 7 Relay |
| 3 BMS | | |

2) INSPECTION PROCEDURES

① Daily inspection before starting

- Make sure that the battery pack charging terminal (DIN320 connector) is disconnected on the charge.
- Check the battery pack charging terminal for fixed state.
- Check the battery pack charging terminal for damage.
- Check the battery pack charging terminal and system load for fixed state.

② Measures for abnormality before starting

Voltage on charging and discharging terminals of battery pack.

- Servicing is required for troubleshooting of failure by molten relay, short on both ends of relay.
- Servicing is required in cases of function failure of BMS, or power supply to BMS.

Measures for poor stationary conditions of charging and discharging terminals of battery pack.

- Check tightening status of bolts of charging/discharging terminals.
- Fasten the bolt at specified torque.

③ Damage of battery pack charging terminal

- Replace with specified connector (DIN320).
- Checking for defects after start stopping
- Check if starting is stopped before connecting charging terminal on battery pack charging terminal.
- Check if voltage is detected before connecting charging terminal on battery pack charging

terminal.

- Check the battery pack charging terminal for damage.

④ Measure for defects after start stopping Measure for defects after start stopping

When starting is not stopped When starting is not stopped

- Starting should be stopped.

Voltage detected on charger terminal Voltage detected on charger terminal

- Make sure that starting is stopped. If so, take servicing action.
- Failure by molten relay is suspected. Take servicing action.

Charging terminal of charger or battery pack damaged Charging terminal of charger or battery pack damaged

- Replace with specified connector (DIN320)

3) Precautions

- ① It is strictly prohibited to work outdoors in rain and snow weather, to prevent the battery from entering water. In transportation and installation, waterproof measures should also be taken.
- ② Battery overload work is strictly prohibited.
- ③ When the battery is used in summer, pay attention to the ambient temperature (not higher than 50 degrees), and the charging area should not be exposed to the sun.
- ④ When the battery is used in winter, the vehicle needs to heat before working:
First turn on the power and let the vehicle run slowly for 5-10 minutes, then stop and slowly stretch the crane boom, avoid battery not active at low temperature, causing large current battery discharge and even over-current protection.
- ⑤ It is recommended to charge the battery before SOC lower than 20%. If over-discharge, the battery life will be affected (do not overcharge).
- ⑥ Keep high SOC of lithium battery to protect the cell, fully charge when not in use.
- ⑦ When charging wait till the charger stop and calibrated automatically. (Not fully charged for a long time will lead to a deviation from the actual SOC.)
- ⑧ Long-term storage requires charging and maintenance every three months.
Before using it again, please confirm that the power battery system has no fault alarm. Please contact our after-sales service for maintenance when needed.

4) Fault codes and phenomena of lithium battery

Code	Fault information	Fault grade
1	BMS CUTBACK	Secondary fault , Traction speed reduced to 50%
2	BMS INHIBIT	Limit traction and oil pump functions
3	BMS ALARM	First-class fault, Show only fault codes. Vehicles are unlimited
4	BMS INHIBIT	Limit traction and oil pump functions
5	BMS INHIBIT	Tertiary fault, Limit traction and oil pump functions, After 30S, the battery will automatically cut off power
6	discharge cell temp.low_1	First-class fault

Code	Fault information	Fault grade
7	discharge cell temp.low_2	Secondary fault
8	discharge cell temp.low_3	Tertiary fault
9	discharge cell temp.hig_1	First-class fault
10	discharge cell temp.hig_2	Secondary fault
11	discharge cell temp.hig_3	Tertiary fault
12	cell voltage low_1	First-class fault
13	cell voltage low_2	Secondary fault
14	cell voltage low_3	Tertiary fault
15	cell voltage high_1	First-class fault
16	cell voltage high_2	Secondary fault
17	cell voltage high_3	Tertiary fault
18	cell voltage differ_1	First-class fault
19	cell voltage differ_2	Secondary fault
20	cell voltage differ_3	Tertiary fault
21	cell temp. differ_1	First-class fault
22	cell temp. differ_2	Secondary fault
23	cell temp. differ_3	Tertiary fault
24	SOC LOW_1	First-class fault
25	SOC LOW_2	Secondary fault
26	SOC LOW_3	Tertiary fault
27	discharge current high_1	First-class fault
28	discharge current high_2	Secondary fault
29	discharge current high_3	Tertiary fault
30	Module lost connection_1	First-class fault
31	Module lost connection_2	Secondary fault
32	Module lost connection_3	Tertiary fault
33	cell temp.sensor fault_1	First-class fault
34	cell temp.sensor fault_2	Secondary fault
35	cell temp.sensor fault_3	Tertiary fault
36	total voltage low_1	First-class fault
37	total voltage low_2	Secondary fault
38	total voltage low_3	Tertiary fault
39	total voltage high_1	First-class fault
40	total voltage high_2	Secondary fault
41	total voltage high_3	Tertiary fault
42	discharging relay fault_1	First-class fault
43	discharging relay fault_2	Secondary fault
44	discharging relay fault_3	Tertiary fault
45	battery leakage_1	First-class fault
46	battery leakage_2	Secondary fault
47	battery leakage_3	Tertiary fault
49	Battery heating .Vehicle stops	First-class fault

5) Troubleshooting

Faults	Description	Fault causes	Troubleshooting	Remark
Battery cannot charge, can discharge	The vehicle can work normally, no alarm from buzzer, charger display: please connect the battery.	<ul style="list-style-type: none"> · Charging plug loose. · Poor wire contact of charging relay. · The charging relay stuck. 	<ul style="list-style-type: none"> · Reconnect the charging plug. · Check the connection of charging relay power line. · Replace relay. 	The stuck relay may close temporarily if being beaten, replace it once new parts is available.
	The vehicle can work normally, no alarm from buzzer, charger display: communication error.	<ul style="list-style-type: none"> · The CAN pin-out of charging plug not match. · The charging plug CAN pin break. 	<ul style="list-style-type: none"> · Replace the CAN pin-out of battery or charger plug. · Reinstall the CAN line of charging plug. 	
	Output voltage still there after turning off the vehicle key switch. Buzzer alarm and charger display: please connect the battery.	Discharge relay contact adhesion	Replace the discharge relay.	
Unable to charge, unable to discharge	Vehicle cannot move, buzzer alarms, the charger has a voltage and no current	Charging relay contact adhesion	Replace the charging relay	
	Vehicle cannot move, fault alarm level 3 (not including SOC low)	Level 3 fault alarm	Check the relevant components and parameter settings according to the fault code	
	Vehicle cannot move, cannot charge	<ul style="list-style-type: none"> · Switch fault or switch wiring disconnected · Fuse damage · DC damage · BMS fault · Low SOC due to battery over-discharge or long-time storage. 	<ul style="list-style-type: none"> · Replace the switch or wiring repair · Replace the fuse and check other components · Replace DC · Replace BMS · Recharge the battery 	Do check the vehicle short circuit if the fuse is damaged and the relay is contact adhesion. (Battery without auxiliary power supply.)

Faults	Description	Fault causes	Troubleshooting	Remark
	Vehicle cannot move, cannot be charged, charger display: please connect the battery.	The fuse is damaged.	Replace the fuse	Battery with auxiliary power supply.
Can be charged, unable to discharge	The battery can be charged, unable to discharge	DC damage	Replace DC	Battery with auxiliary power supply.
Short charging time and short discharge time	The battery is fully charged very quickly when charging, and the power supply drops very quickly when discharging.	<ul style="list-style-type: none"> · Module cell breakdown. · BMS wiring harness damage. · BMS parameter setting error. 	<ul style="list-style-type: none"> · Replace the module · Replace the BMS wiring harness · Reset the BMS parameter or update the program 	
Small charging current	Charging current value is much less than the BMS request current, fault indicator of charger is on.	Some module of the charger fails	Replace the charger module or replace the charger directly	Charging current value is much less than the BMS request current, fault indicator of charger is on.
	Charging current of the charger is about 30A @ 0-5℃	Low temperature	Charging current 30A @ 0-5℃ is normal, current will returns and fault code disappears with the increase of cell temperature.	Charging current of the charger is about 30A @ 0-5℃
Low SOC	Alarm when SOC > 15%: (for example 22%´ 60%)	<ul style="list-style-type: none"> · BMS failure · BMS wiring broken or loose · Battery unused for a long time (actual voltage is inaccurate) 	<ul style="list-style-type: none"> · Replace BMS · Replace or reinforce the wiring harness of connector · Battery full charge then calibrate 	Low SOC
Intermittent power failure	The vehicle is powered off repeatedly during operation	<ul style="list-style-type: none"> · Relay power line poor contact · Relay breakdown 	<ul style="list-style-type: none"> · Check the relay power line and reinforce it. · Replace the relay. 	Poor power supply by BMS; excessive battery pressure difference will cause the same fault.

9. Lithium Battery Charger

1) Parameters

Project	Parameter Index	
All-in-one type	CD18-80V100ALI	CD18-80V200ALI
DC Output		
Maximum Output Power	10kW	20kW
Rated Output Current	100A	200A
Output Voltage Range	30VDC~100VDC	40VDC~100VDC
Current Limit Adjustable Range	2A~100A	2A~200A
Peak-to-peak Noise	$\leq 1\%$	
Stabilization Accuracy	$\leq \pm 0.5\%$	
Steady Flow Accuracy	$\leq \pm 1\%$	
Current Sharing	$\leq \pm 3\%$	
Effectiveness	Overall efficiency $\geq 94\%$	
Protection	Short circuit, over current, over voltage, reverse connection, current backflow protection	
AC Input		
Rated Input Voltage	Three-phase four-wire system 380Vac $\pm 15\%$	
Input Voltage Range	280Vac~480Vac	
Input Current	20A	40A
Frequency	45Hz~65Hz	
Power Factor (PF)	≥ 0.99	
Current Distortion	$\leq 5\%$	

Project	Parameter Index
Input Protection	Overvoltage, undervoltage, phase loss, overcurrent protection
Working Environment Conditions	
Working Temperature	-30℃~55℃ normal operation; 57℃~75℃ derating output; 75℃ or more shutdown protection
Storage Temperature	-30℃~75℃
Relative Humidity	0~95%
Altitude	≤2000m full load, 2000~3000m in accordance with GB/T3859.2-1993 5.11.2 predetermined, derating
Product Safety and Reliability	
Dielectric Strength	Input - output: 3000VAC/10Ma/1Min Input - Shell: 2500VAC/10Ma/1Min Output - shell: 2500VAC/10Ma/1Min
	Input - output: DC1000V>20MΩ Input - Shell: DC1000V>20MΩ Output - shell: DC1000V>20MΩ
Dimensions and Weight	
Dimensions (Host)	481 (length) × 430 (width) × 731 (height)
Protection Level	IP21
All-in-one Net Weight	51Kg
Other	
Output plug-in Specifications	Comply with GB/T 20234.1-2011 and GB/T 20234.3-2011
Cooling Method	Forced air cooling

2) Installation

① Installation and wiring of the charger

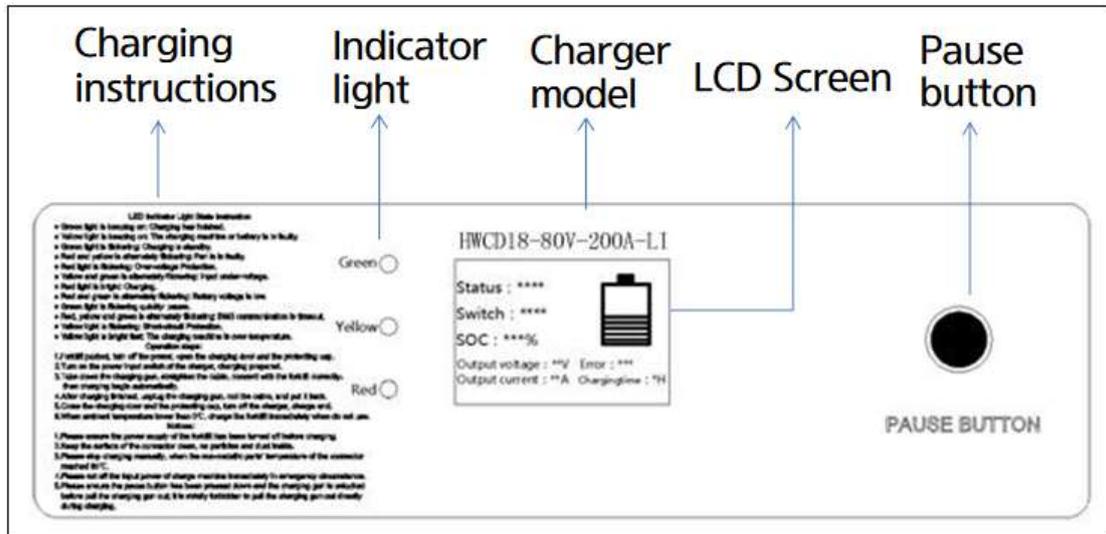
② Precautions for charger installation:

- Confirm the model and specifications of the charger.
- Check if the random materials and attachments are complete.
- Check whether the charger is damaged due to collision, water ingress, etc.
- Check whether the relevant electrical parts are loose or damaged.

③ Installation steps of charger:

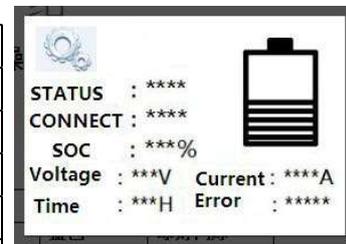
- Confirm the working environment of the charger.
- Determine whether the AC power supply can meet.
- Unpacking and testing of the charger.
- Input line access.
- Power on.
- Trial run.

3) Charger interface



① Display status

Charger Status	Background	Battery Icon	Light Status
Standby	Blue	Blue	Flashing Green
Recharge	Green	Orange	Red lights Always On
Time Out	Blue	Orange	Flashing Red
Malfunction	Red	Orange	Fault Status Indication
Carry Out	Blue	Green	Steady Green



② Working status

There are 5 working statuses of this charger: "standby", "charge", "completed", "suspended" and "faulty".

Standby: When the charger is powered on, and the charging connector head is not connected to the battery or the connection is bad, the power display at this time is 0%, and the battery graphic shows 0 grid; when the charging connector head is unplugged during charging, it also shows standby.

Charging: The connector head is connected normally (CC1 confirms and the message is normal), at this time the battery level shows the battery level value.

Completion: charging is complete, the battery level shows 100%.

Pause: When the manual pause button is pressed, pause is displayed, output is stopped, and the battery power value is displayed on the battery level.

Fault: When the battery or the charger itself fails, the charging status becomes fault, the module stops output, the background color of the display is red, and the fault message indicates the fault phenomenon.

③ Charging connection

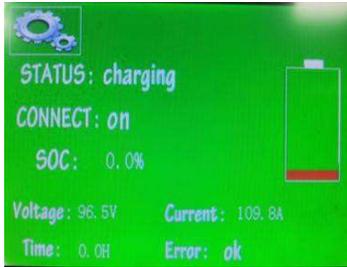
displayed as "normal" or "disconnected". Disconnected: "When the charging connector is pulled out" or "Switch S is pressed", it will display "Disconnected"; Normal: When the charging connection is normal, it will display "Normal".

④ LCD display page turning interface

Touch the dot mark  on the display screen by hand to enter the next interface, enter the

charger and battery connection message and information, and then click the "return" mark to return to the previous interface.

Touch  with your hand to enter the next interface. There are three functions: current limit setting, scheduled charging, and forced charging.



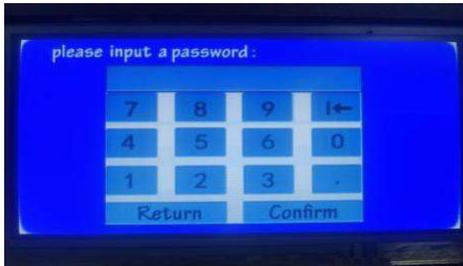
Normal charging



Message and information



Three functions



Password: 6666



Current limit setting



Schedule charging



Forced charging



Language setting

4) Charging operation steps

Step 1: charge preparation

- ① Park the forklift in the charging area and turn off the key switch of the vehicle.
- ② Open the vehicle charging compartment door and protective cover, and check the charging interface.
- ③ Confirm the status of the charger and check the charging connector.

Step 2: Charging starts

- ① Correctly connect the charging connector to the vehicle charging interface.
- ② Observe the charging connection and working status in the display of the charger, the display is blue. Wait for the charging confirmation for about 15 seconds, the charging current is normal, the display is green, and charging starts.

Step 3: End of charging

- ① After confirming that the charging current in the charger is displayed as 0A, pull out the charging connector correctly.

- ② The charger is not fully charged, and the display current is not 0A, please press the pause button, after the charging current is displayed as 0A, pull out the charging connector correctly.
- ③ Close the charging protective cover and hatch, and place the charging connector in a standard manner.
- ※ Before charging, make sure that the power of the forklift is turned off.
 - Keep the surface of the charging interface clean, and there are no particles, dust and other debris in the interface.
 - When the temperature of the non-metal part of the charging interface is too high, please stop charging immediately.
 - Before pulling out the charging connector, please make sure that the charging is completed or press the charging pause button, and confirm that the charging current is displayed as 0A;
 - The charging temperature range is: 0~40°C, low temperature environment below 0°C, please charge the vehicle immediately after use;
 - When storing the vehicle, please make sure that the battery power is around 50%, and disconnect the battery from the vehicle.

5) Failure analysis

This smart charger intelligently recognizes the fault of the battery BMS, and displays the fault information on the charger interface. At the same time, it can self-check the charger's input and output current, voltage, and the temperature of the charging connector, and judge the charger fault based on this.

Fault query list

Fault Category	No.	Fault Information	ABBR.	Remark
Electric Supply Fault	1	Input under-voltage	Input under-volt	Check the electric supply.
	2	Input overvoltage	Input over-volt	
	3	Input fault	Input fault	
	1	Short circuit protect	Short circuit	Check the charger.
	2	Charger over-temperature protection	Charger overtemperature	
	3	Communication module timeout	CM timeout	
	4	Hardware fault	Hardware fault	
Battery Fault	1	Battery overcharge protect	BAT overcharge	Check the battery.
	2	Over-temperature protect	BAT overtemperature	
	3	Lower-temperature protect	Lower-temp	
	4	Cell voltage lower	Cell-volt lower	
	5	Charging overcurrent	Overcurrent	
	6	BMS Fault	BMS Fault	
	7	cells voltage difference	Cell-volt DIFF	
	8	cells Temp difference	Cell-temp DIFF	
	9	Insulation fault	Insulation fault	
	10	Undefined	Undefined	
Other Faults	1	BMS Timeout	BMS Timeout	Check the charger's connection.

Troubleshooting

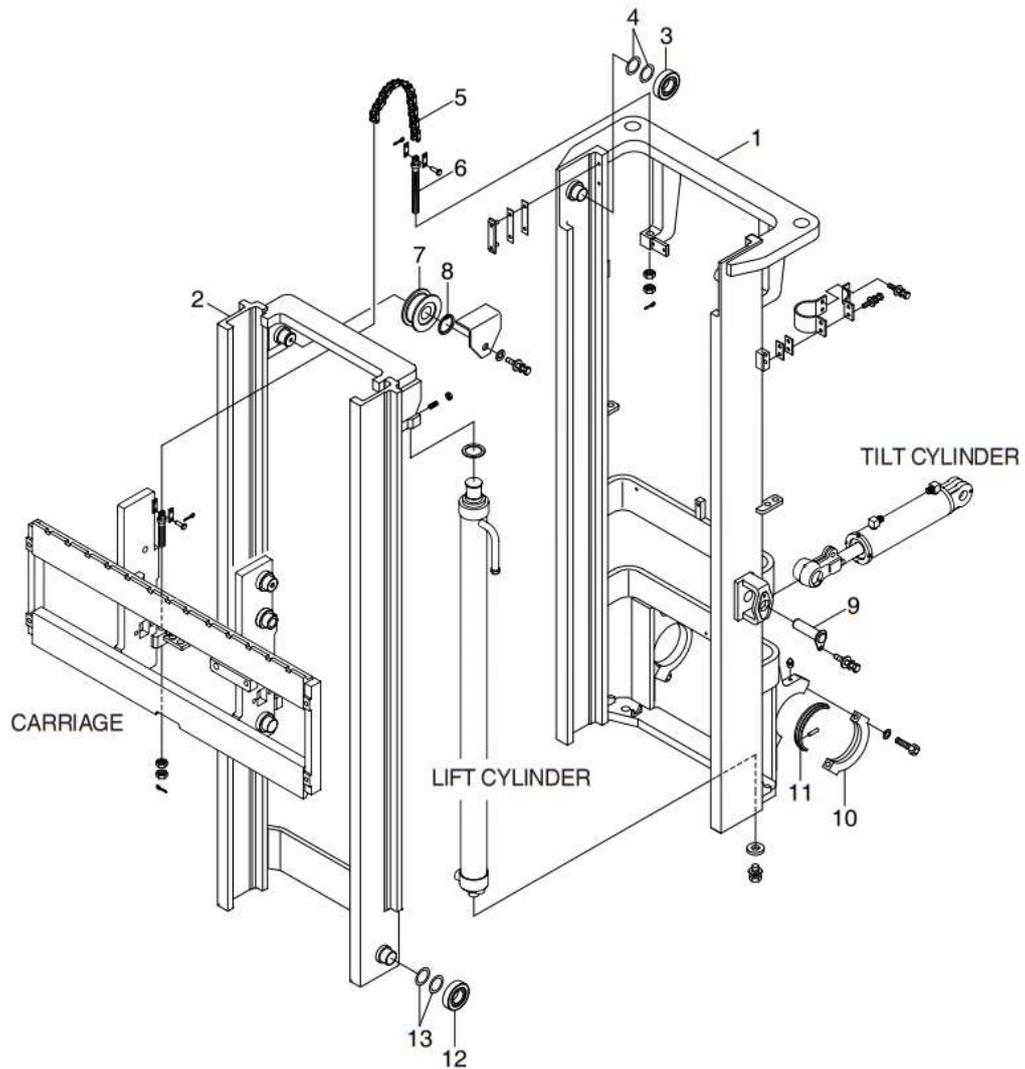
NO.	Phenomenon	Information in LCD screen	Fault Investigations
1	LCD screen and LED lights on the panel don't brighten after starting machine.	LCD screen shows nothing.	<ol style="list-style-type: none"> 1. Whether the three-phase switch on the side of the charger is in the ON position. 2. Check whether the input three-phase power is connected or not and whether lack of phase. 3. Whether the three-phase fuse in the charger fused. 4. Whether the 12V+ auxiliary power module in the charger is damaged. 5. Whether the 5V power on the LCD is normal. 6. Whether the LCD screen is broken.
2	It can't charge after starting machine. LCD screen brightens and green LED light flickers.	Status: standby Error: ok Voltage: 0V SOC: 0.0%	<ol style="list-style-type: none"> 1. Whether connect the charging connector and the forklift well. 2. Click the battery icon to enter the next interface on LCD screen. If screen shows that 'Whether receive the message of the charger: 'NO'', the control panel of the charger was broken. 3. Whether receive the message of the charger: 'YES'. Whether receive the message of BMS: 'NO'. <p>Check whether the +12V power of the charge connector A+ and A- is normal or not. If normal, it is the battery problem, please contact the battery manufacturer.</p>
3	It can't charge after starting machine. LCD screen brightens and green LED light flickers.	Status: standby Error: ok Voltage: 0V SOC: 0.0%	<ol style="list-style-type: none"> 1. Whether connect the charging connector and the forklift well. 2. Click the battery icon to enter the next interface on LCD screen. If it shows: Whether receive the message of the charger: 'NO'. Whether receive the message of BMS: 'NO'. <p>The +12V power is broken. Please replace the +12V auxiliary power.</p>

NO.	Phenomenon	Information in LCD screen	Fault Investigations
4	It can't charge after starting machine. LCD screen brightens and green LED light flickers.	Status: standby Error: ok Voltage: 0V SOC: **. *%	<ol style="list-style-type: none"> 1. Confirm whether the charging connectors and sockets connect well. 2. Open the back door of charger, measure the voltage between positive and negative terminals with multi-meter, which connect the charging connector and the charger. <ol style="list-style-type: none"> 2.1 If voltage can't be measured, the battery has problem. 2.2 If voltage can be measured, then measure the voltage between OUT+ and OUT- terminals. If voltage still can be measured, then the control panel is broken. <p>Otherwise, check further whether 300A fuse, pre-charge resistors and diodes between the two ends of the output contactor are broken or not.</p>
5	It can't charge after starting machine. LCD screen and red LED light both brighten.	Status: standby Error: ok SOC: **. *% Battery Voltage: **. *% Current: 0A	The output contactor is damaged (charging voltage reaches BMS demand voltage).
6	It charges after starting machine. LCD screen and red LED light both brighten. Charging current is less than BMS required current.	Status: standby Error: one module work SOC: **. *% Voltage: **. *V Current: 100A	<ol style="list-style-type: none"> 1. Check whether the input power of the charging module is normal and whether the connector is loose. 2. Check whether the output connector of the charging module is loose. 3. Check whether CAN communication connecting line is loose. If the above checks are normal, the charging module is broken.
7	It can't charge after starting machine. LCD screen and yellow LED light both brighten.	Status: fault Error: input fault Voltage: **. *V SOC: **. *%	Input is lack of phase. Check the fuse in L3 phase and three-phase circuit breaker of the charger. Electricity connected to the charger is lack of L3 phase.
8	It can't charge after starting machine. LCD screen and yellow LED light both brighten. Meanwhile, charger starts repetitively.	Status: fault Error: input fault Voltage: **. *V SOC: **. *%	Input is lack of phase. Check the fuse in L1 or L2 phase and three-phase circuit breaker of the charger. Electricity connected to the charger is lack of L1 or L2 phase.

SECTION 8 MAST

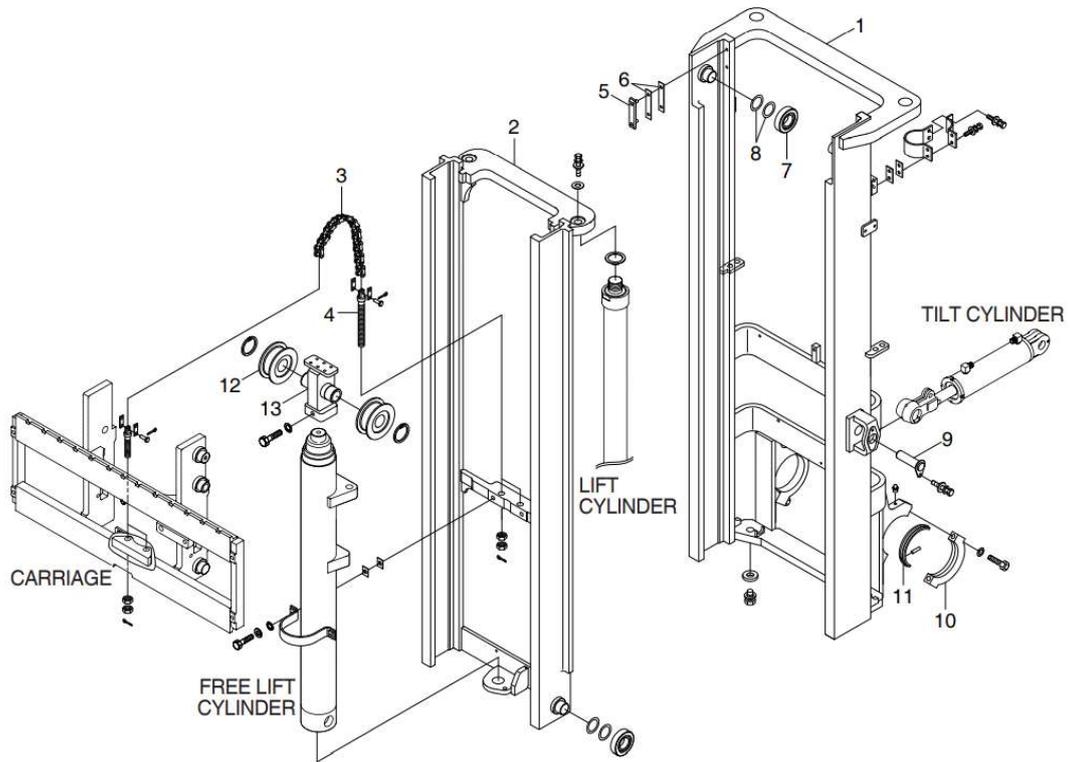
GROUP 1 STRUCTURE

1. 2 STAGE MAST (V MAST)



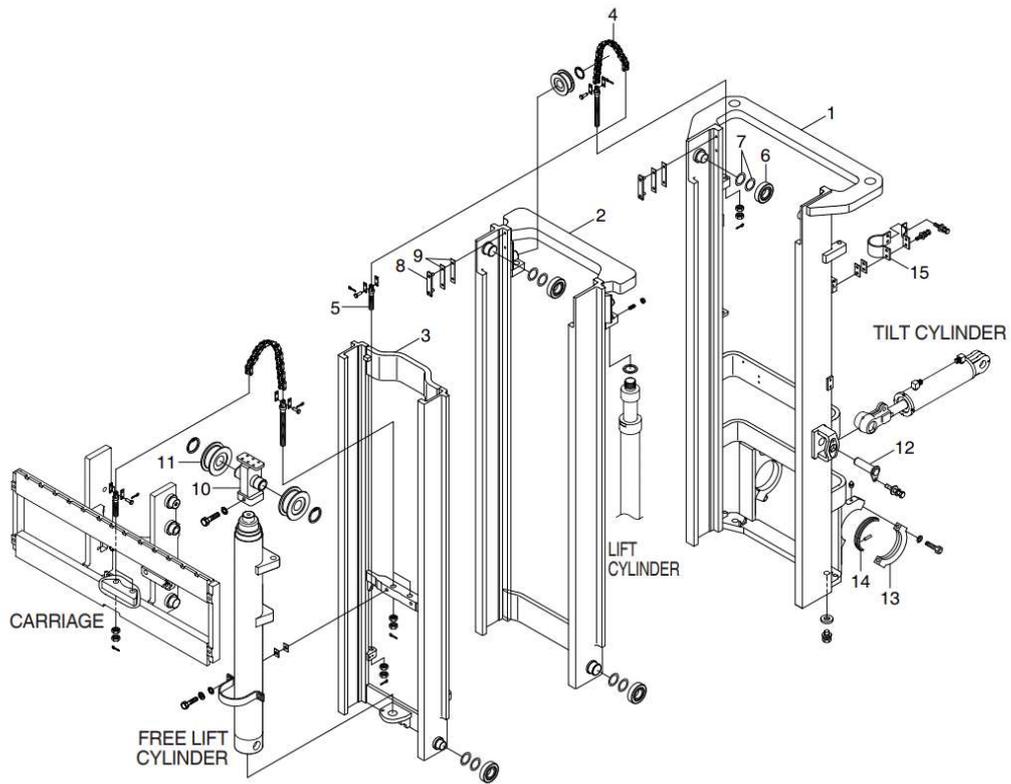
- | | | | | | |
|---|-----------------|----|-------------------|----|------------------|
| 1 | Outer mast | 6 | Anchor bolt | 11 | Bushing |
| 2 | Inner mast | 7 | Sheave bearing | 12 | Roller |
| 3 | Roller | 8 | Retaining ring | 13 | Shim (0.5, 1.0t) |
| 4 | Shim (0.5 1.0t) | 9 | Tilt cylinder pin | | |
| 5 | Chain | 10 | Trunnion cap | | |

2. 2 STAGE MAST (VF MAST)



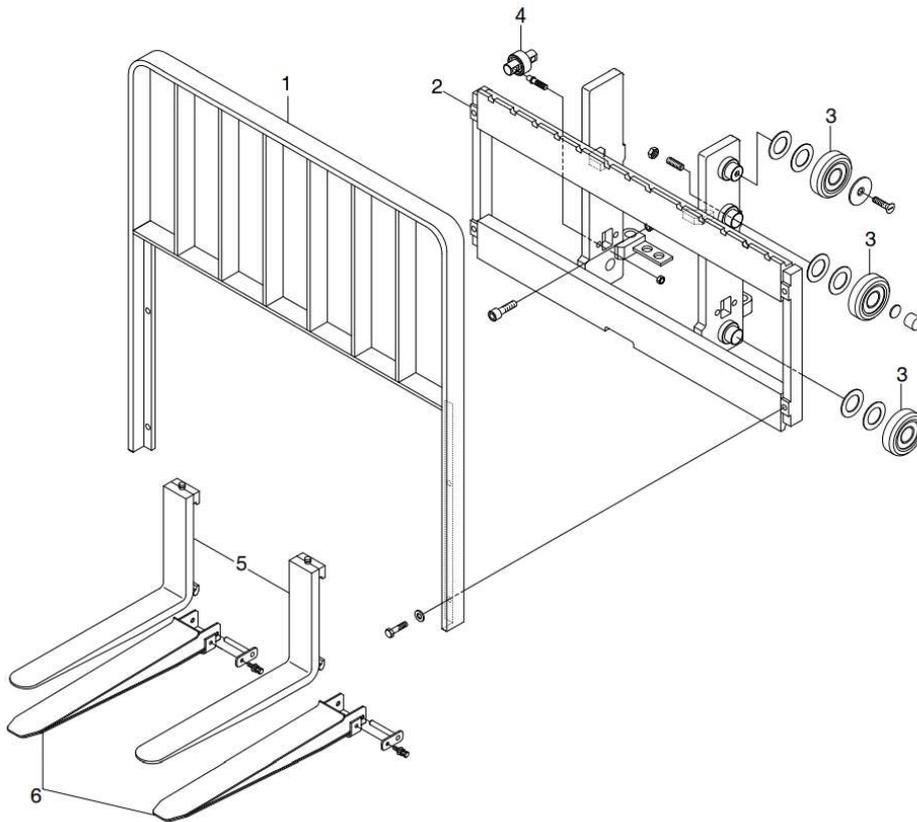
1	Outer mast	6	Shim (0.5, 1.0t)	11	Bushing
2	Inner mast	7	Roller	12	Sheave bearing
3	Chain	8	Shim (0.5, 1.0t)	13	Shim (0.5, 1.0t)
4	Anchor bolt	9	Tilt cylinder pin		
5	Backup liner	10	Trunnion cap		

3. 3 STAGE MAST (TF MAST)



- | | | | | | |
|---|-------------|----|------------------|----|---------------------|
| 1 | Outer mast | 6 | Roller | 11 | Chain wheel bearing |
| 2 | Middle mast | 7 | Shim (0.5, 1.0t) | 12 | Tilt cylinder pin |
| 3 | Inner mast | 8 | Backup liner | 13 | Trunnion cap |
| 4 | Chain | 9 | Shim (0.5, 1.0t) | 14 | Bushing |
| 5 | Anchor bolt | 10 | Bearing bracket | 15 | Clamp |

4. CARRIAGE, BACKREST AND FORK



- | | | | | | |
|---|----------|---|--------------|---|----------------|
| 1 | Backrest | 3 | Load roller | 5 | Fork assembly |
| 2 | Carriage | 4 | Sider roller | 6 | Extension fork |

GROUP 2 OPERATIONAL CHECKS AND TROUBLESHOOTING

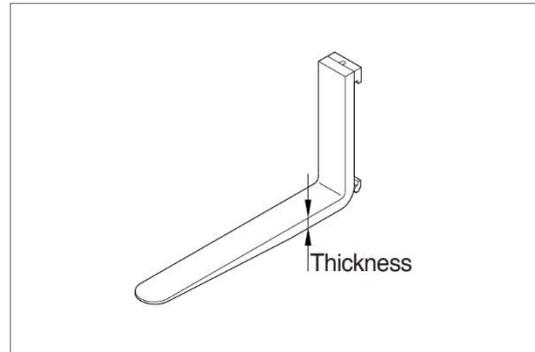
1. OPERATIONAL CHECKS

Fork

- 1) Measure thickness of root of forks and check that it is more than specified value.

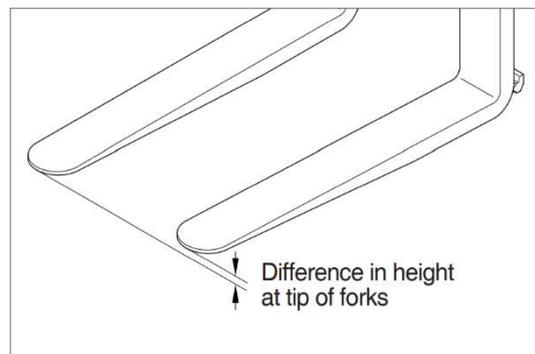
STD Fork assy	Model	Standard	Limit
64FG-31020C	25BE-X	45mm	40mm
64FG-31030C	30/35BE-X	45mm	40mm

Length: 1050mm



- 2) Set forks in middle and measure out of parallel and difference in height at the top of forks.

Model	Length	Height difference
Overall	≤ 1500mm	3mm
	> 1500mm	4mm



- 3) Most force is concentrated at root of fork and at hook, so use crack detection method to check cracks.

Mast

- 1) Check for cracks at mast stay, tilt cylinder bracket, guide bar, fork carriage and roller shaft weld. Check visually or use crack detection method. Repair any abnormality.
- 2) Set mast vertical, raise forks about 10 cm from ground and check front-to-rear clearance and left-to-right clearance between inner mast and fork carriage, and between outer mast and inner mast. Use these figures to judge if there is any play at roller or rail.
 - Front-to-rear clearance: Within 2.0 mm
 - Left-to-right clearance: Within 2.5 mm
- 3) Check that there is an oil groove in bushing at mast support.
- 4) Set mast vertical, raise forks about 10cm from ground, and push center of lift chain with finger to check for difference in tension. If there is any difference in tension, adjust chain stopper bolt
- 5) Check visually for abnormalities at thread of chain anchor bolt, and at contact surface between chain wheel and chain. Rotate chain wheel by hand and check for any play of bearing.

2. TROUBLESHOOTING

1) Fork

Problem	Cause		Remedy
Abrasion	Long-time operations cause the fork to wear and reduces the thickness of the fork. Inspection for thickness is needed · Wear limit: Must be 90% of fork thickness		If the measured value is below the wear limit, replace fork.
Distortion	Forks are bent out of shape by a number of reasons such as overloading, glancing blows against walls and objects, and picking up load unevenly · Difference in fork tipheight		If the measured value exceeds the allowance, replace fork.
	Length	Height difference	
	≤ 1500mm	3mm	
	> 1500mm	4mm	
Fatigue	Fatigue failure may result from the fatigue crack even though the stress to fork is below the static strength of the fork. Therefore, a daily inspection should be done. · Crack on the fork heel. · Crack on the fork weldments		Repair fork by expert. In case of excessive distortion, replace fork.

2) Mast

Problem	Cause	Remedy
Forks fail to lower.	· Deformed mast or carriage.	· Disassemble, repair or replace.
Fork fails to elevate	· Faulty hydraulic equipment. · Deformed mast assembly.	· See troubleshooting hydraulic pump and cylinders in section 6, Hydraulic system. · Disassemble mast and replace damaged parts or replace complete mast assembly.
Slow lifting speed and insufficient handling capacity.	· Faulty hydraulic equipment. · Deformed mast assembly.	· See troubleshooting hydraulic pump and cylinders in section 6 Hydraulic system. · Disassemble mast and replace damaged parts or replace complete mast assembly.
Mast fails to lift smoothly.	· Deformed mast or carriage. · Faulty hydraulic equipment. · Damaged load and side rollers. · Unequal chain tension between LH & RH sides. · LH & RH mast inclination angles are unequal. (Mast assembly is twisted when tilted)	· Disassemble, repair or replace. · See Troubleshooting Hydraulic Cylinders, pump and control valve in section 6 hydraulic system. · Replace. · Adjust chains. · Adjust tilt cylinder rods
Abnormal noise is produced when mast is lifted and lowered.	· Broken load roller bearings. · Broken side roller bearings. · Deformed masts. · Bent lift cylinder rod. · Deformed carriage. · Broken sheave bearing	· Replace. · Replace. · Disassemble, repair or replace. · Replace. · Replace. · Replace.
Abnormal noise is produced during tilting operation.	· Insufficient lubrication of anchor pin, or worn bushing and pin. · Bent tilt cylinder rod.	· Lubricate or replace. · Replace.

GROUP 3 ADJUSTMENT

1. MAST LOAD ROLLER (V, VF MAST)

INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

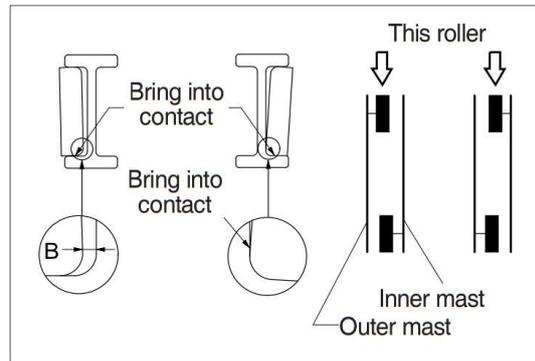
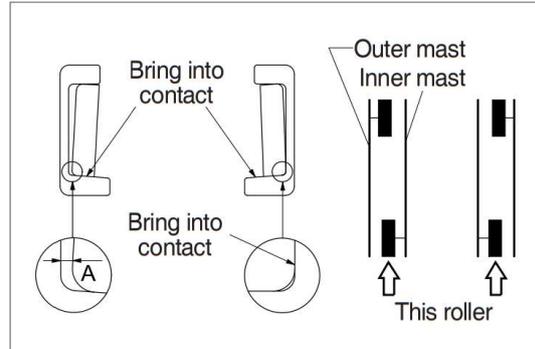
1) Measure the clearance with the mast overlap at near 480 mm.

2) Shift the inner mast to one side to bring the roller into contact with the outer mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner/outer mast roller shim

- Standard clearance A, B = 0~0.6 mm
- Shim thickness 0.5, 1.0 mm

3) Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.

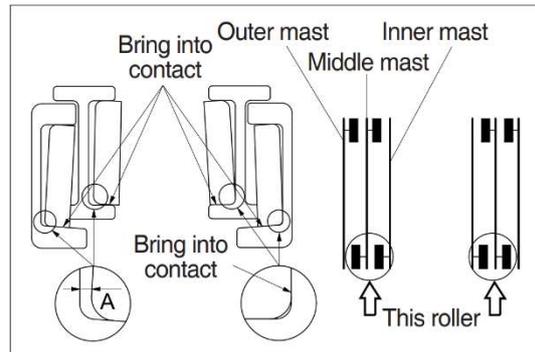
4) After the adjustment, check that the inner mast moves smoothly in the outer mast.



2. MAST LOAD ROLLER (TF MAST)

1) INNER/OUTER MAST ROLLER CLEARANCE ADJUSTMENT

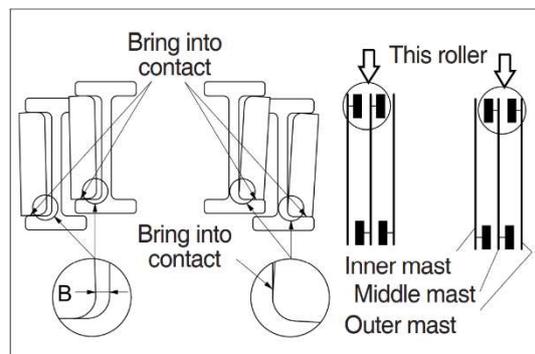
- ① Measure the clearance with the mast overlap at near 480 mm.
- ② Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the inner and middle mast roller shim, respectively.



- Standard clearance $A = 0 \sim 0.6$ mm
 - Shim thickness 0.5, 1.0 mm
- ③ Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.
 - ④ After the adjustment, check that the inner mast moves smoothly in the middle mast, and the middle mast moves smoothly in the outer mast.

2) OUTER AND MIDDLE MAST ROLLER CLEARANCE ADJUSTMENT

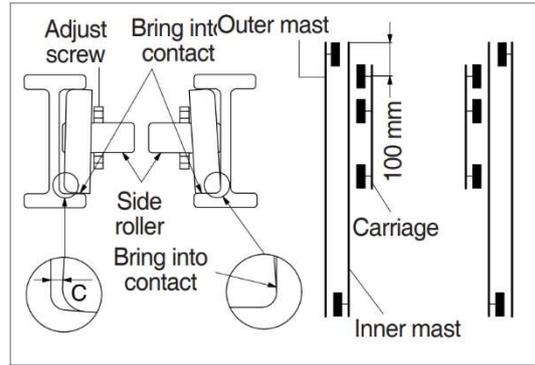
- ① Measure the clearance with the mast overlap at near 480 mm.
- ② Shift the inner mast to one side to bring the roller into contact with the outer mast and the middle mast, and adjust the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the outer and middle mast roller shim, respectively.



- Standard clearance $B = 0 \sim 0.6$ mm
 - Shim thickness 0.5, 1.0 mm
- ③ Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation
 - ④ After the adjustment, check that the inner mast moves smoothly in the middle mast, and the middle mast moves smoothly in the outer mast.

3) CARRIAGE LOAD ROLLER

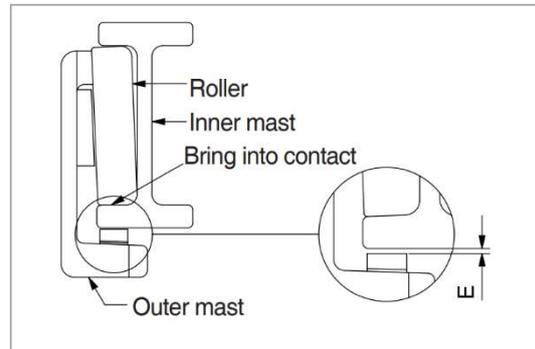
- ① Measure the clearance when the center of the carriage upper roller is 100 mm from the top of the inner mast.
- ② Measure the clearance at upper, middle and lower rollers after loosen the adjust screws from the side rollers. Shift the carriage to one side to bring the roller into contact with the inner mast, and measure the clearance between the roller side face and mast at the closest position on the opposite side to the following value by inserting the carriage roller shim.



- Standard clearance $C = 0 \sim 0.6$ mm
 - Shim thickness 0.5, 1.0 mm
- ③ Distribute the shim thickness equally to the left and right roller. Refer to Mast load roller and back up liner, removal and Installation.
 - ④ After the adjustment, the carriage should move smoothly along the overall mast length.

4) MAST BACKUP LINER

- ① Measure the clearance with the middle mast at the bottom position
- ② With the middle mast in contact with the outer mast roller, adjust the clearance between the mast back up liner and middle mast to the following value by inserting the back up liner shim.

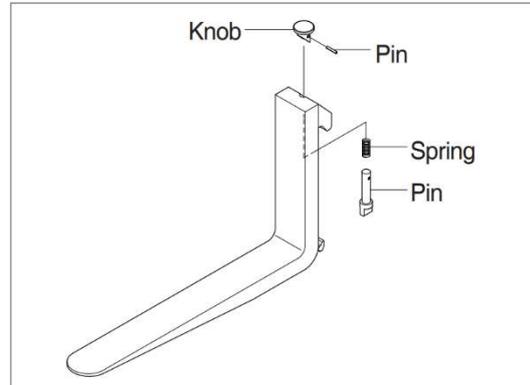


- Standard clearance $E = 0.2 \sim 0.6$ mm
 - Shim thickness 0.5, 1.0 mm
- ③ After the adjustment, the mast should move smoothly.

GROUP 4 REMOVAL AND INSTALLATION

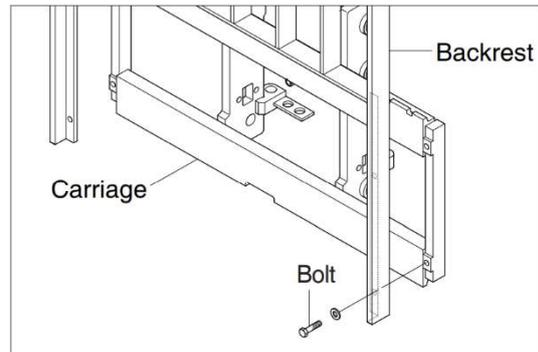
1. Fork

- 1) Lower the fork carriage until the forks are approximately 25 mm from the floor.
- 2) Turn the knob up and slide forks, one by one, toward the center of the carriage where a notch has been cut in the bottom plate for easy fork removal.
- 3) Remove the fork one by one. On larger forks it may be necessary to use a block of wood.
- 4) Reverse the above procedure to install load forks.



2. BACKREST

- 1) Remove bolts securing backrest to fork carriage. Disassemble the backrest from the carriage.
- 2) Position backrest on carriage and lower in place. Install and tighten bolts.



3. CARRIAGE ASSEMBLY

1) CARRIAGE

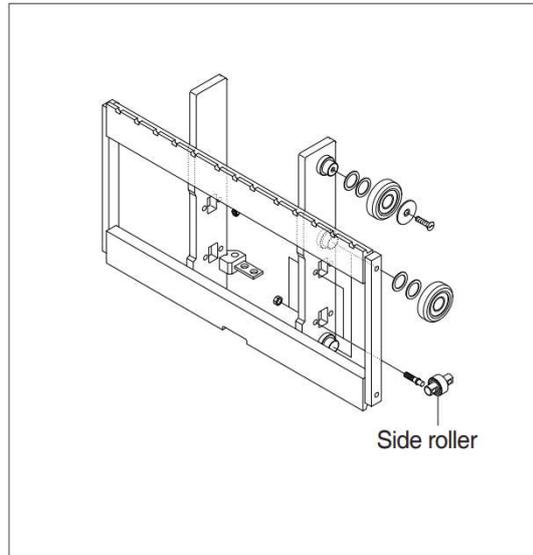
- ① With the mast vertical, raise the carriage high enough to place blocks under the load forks. This is done to create slack in the load chains when the carriage is lowered. Lower the carriage all the way down to the floor. Make sure the carriage is level, this will prevent any binding when the mast is raised.
 - ② While supporting lift chains, remove the split pin and slide out chain anchor pins from the chain anchors of stationary mast.
 - ③ Pull the chains out of the sheaves and drape them over the front of the carriage.
 - ④ Slowly raise elevating mast until mast clears top of fork carriage. Move carriage to work area and lower mast.
- ▲ Make sure carriage remains on floor and does not bind while mast is being raised.
- ⑤ Inspect all parts for wear or damage. Replace all worn or damaged parts.
 - ⑥ Reverse the above procedure to reinstall.
- ▲ Replace the split pin of chain anchor with new one

2) SIDE ROLLER

- ① Remove carriage as outlined in the carriage assembly and removal paragraph.
- ② Loosen and remove nuts, adjust screws and side rollers from carriage side plate.
- ③ Thoroughly clean, inspect and replace all worn or damaged parts.
- ④ Reverse the above procedure to reinstall.

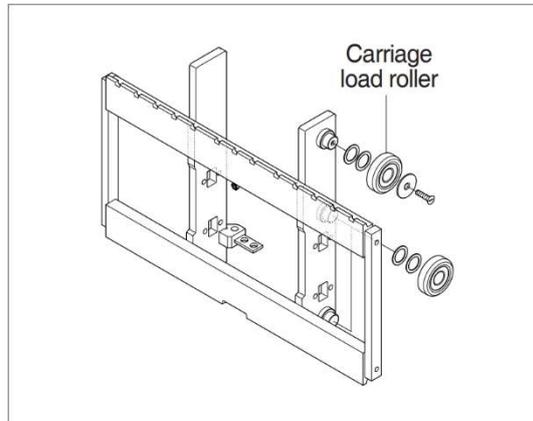
※ Adjustment

- Once carriage is properly installed, loosen nuts and adjust screws, allowing carriage to be centered in the inner mast.
- Adjust side roller by tightening screw until side roller just contact with mast. Back off approximately 1/10 turn on screw and tighten nut to lock screw in place.
- Run carriage up and down for the inner mast to be sure the carriage has free movement and does not stick. Also, make sure chains are properly adjusted. Make adjustment when necessary and recheck operation of carriage.



3) CARRIAGE LOAD ROLLER

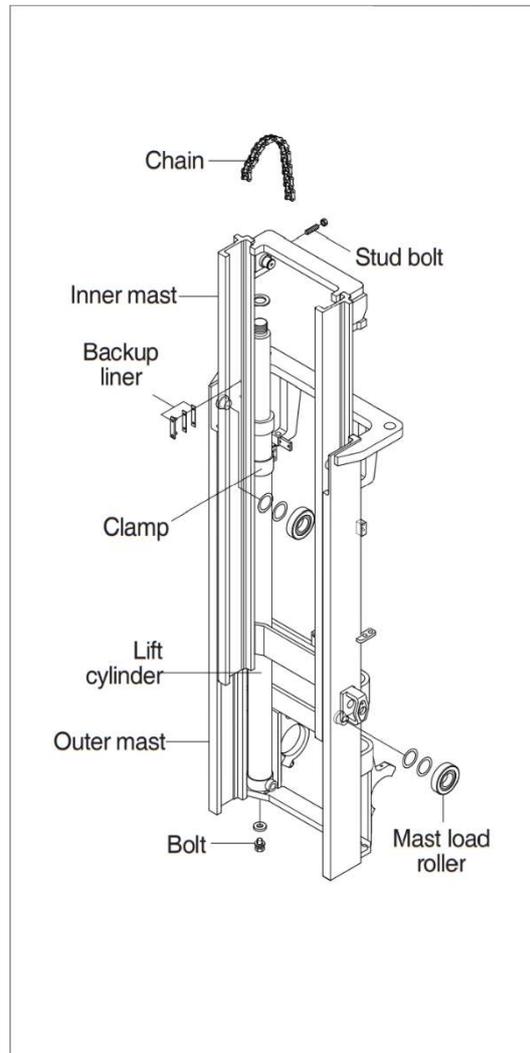
- ① Remove carriage as outlined in the carriage assembly and removal paragraph.
- ② Loosen and remove flat head bolts and plain washers from top load roller bracket.
- ③ Remove load rollers from load roller bracket with a prier.
- ④ Reverse the above procedure to reinstall. Refer to MAST ROLLER ADJUSTMENT paragraph.



4. MAST LOAD ROLLER AND BACKUP LINER

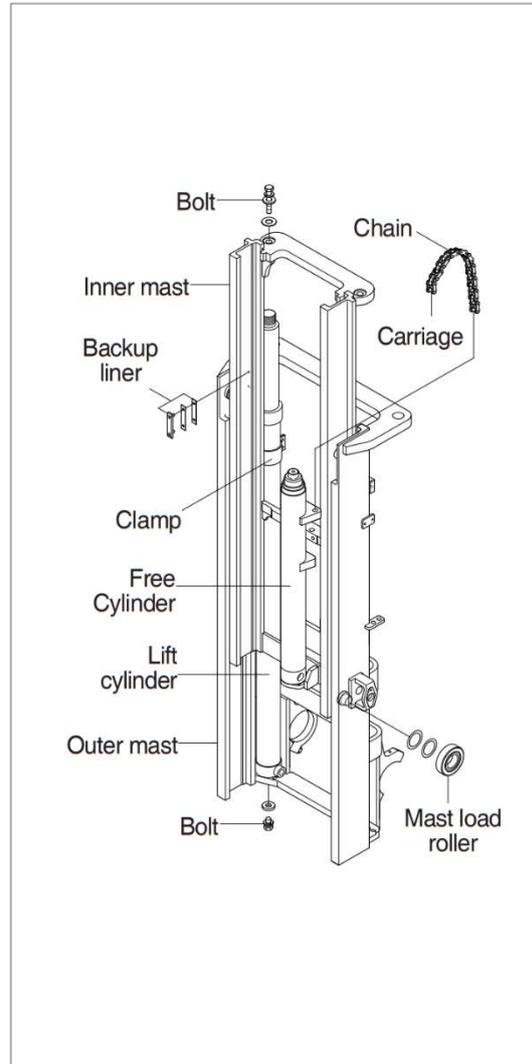
1) 2 STAGE MAST (V MAST)

- ① Remove the carriage assembly and move them to one side.
- ② Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.
- ③ Loosen and remove hexagon bolts and nuts securing lift cylinders to inner mast.
- ④ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
- ⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and then tie them with ropes to the outer mast.
- ⑥ Using the overhead hoist, lower inner mast until top and bottom rollers and back up liners are exposed.
- ⑦ Using a prier, remove load rollers from load roller bracket. Remove back up liners and shims.
- ⑧ Thoroughly clean, inspect and replace all worn or damaged parts
- ⑨ Reverse the above procedure to reinstall. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



2) 2 STAGE MAST (VF MAST)

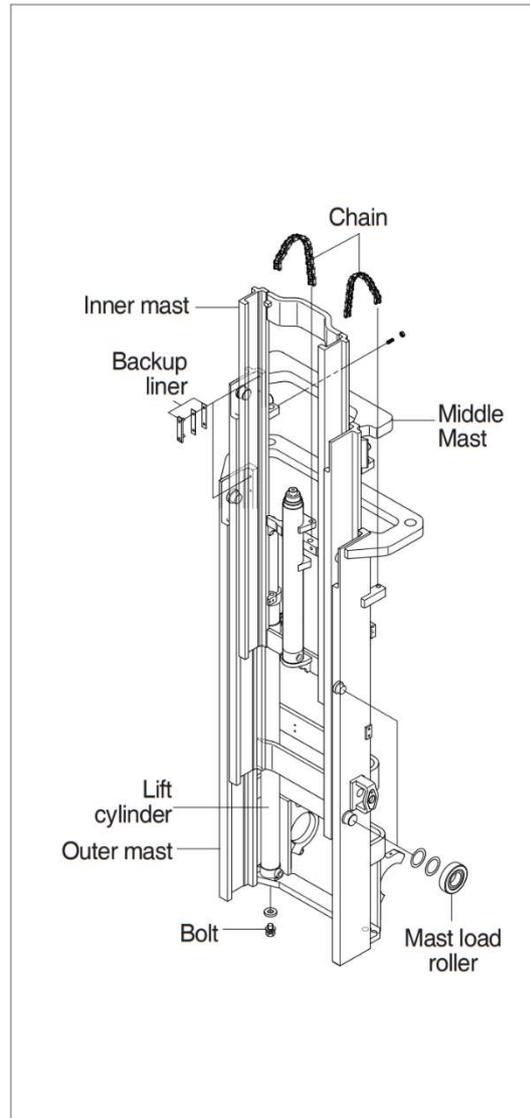
- ① Remove free lift chain connecting carriage and free lift cylinder.
- ② Remove the carriage assembly and move it to one side.
- ③ Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.
- ④ Loosen and remove hexagon bolts and washers securing lift cylinders to inner mast.
- ⑤ Attach chains to the inner mast section at top crossmember. Using an overhead hoist, slowly raise the inner mast high enough to clear lift cylinder.
- ⑥ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and tie them with ropes to the outer mast.
- ⑦ Using the overhead hoist, lower inner mast until top and bottom rollers and back up liners are exposed.
- ⑧ Using a prier, remove load rollers from load roller bracket.
- ⑨ Remove back up liners and shims. Thoroughly clean, inspect and replace all worn or damaged parts.



- ⑩ Reverse the above procedure to reinstall. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.

3) 3 STAGE MAST (TF MAST)

- ① Remove the carriage assembly and move it to one side.
- ② Loosen and remove hexagon bolt securing bottom cylinder from outer mast.
- ③ Loosen and remove band and special washers securing lift cylinders to middle mast. Remove the spring pin.
- ④ Attach chains or sling to the inner and middle mast section at top crossmember. Using an overhead hoist, slowly raise the mast high enough to clear lift cylinder.
- ⑤ After lowering the lift cylinder rods, and disconnecting lift cylinder hose, tilt the lift cylinders LH and RH and then tie them with ropes to the outer mast.
- ⑥ Using the overhead hoist raise inner and middle masts. Place 4 inches block of wood under the free lift cylinder bracket of the inner mast then lower mast sections to create slack in the chains.
- ⑦ Remove retaining rings securing chain sheaves to sheave support brackets.
- ⑧ While supporting chains, remove chain sheaves and let chains hang free. The upper outer and lower middle mast rollers and back up liners are now exposed.
- ⑨ Using a prybar, remove load rollers from load bracket. Remove back up liners and shims.
- ⑩ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist, slowly raise the middle mast until top and bottom rollers are exposed. Using a prybar, remove load rollers from load roller bracket.
- ⑪ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑫ Reverse the above procedure to reinstall. Refer to MAST LOAD ROLLER ADJUSTMENT paragraph.



5. ELEVATING MAST

1) INNER MAST (V, VF MAST)

- ① After completing all necessary steps for load rollers and back up liner removal use an overhead hoist to remove chain around upper crossmember of the inner mast section.
- ② Lift inner mast straight up and out of outer mast section.
- ③ Replace and reverse above procedure to install. Make all necessary measurements and adjustments.

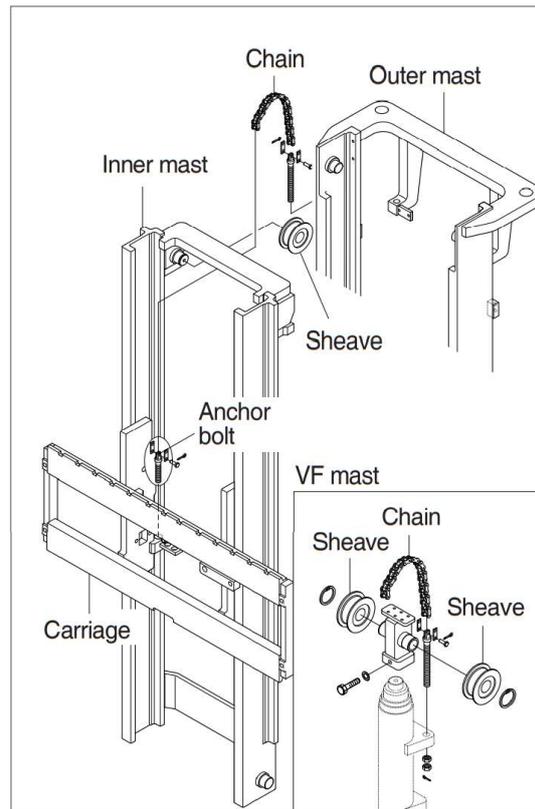
2) Inner and middle mast (TF mast)

- ① Follow all necessary steps for load rollers and back up liner removal. Remove rear chains and sheave support if not already done.
- ② Remove lift cylinder hose. Place hose into a suitable fan or container and close the hose cap.
- ③ While supporting lift cylinder, remove bolts and washers securing cylinder to mast crossmember.
- ④ Place a sling around lift cylinder and attach to an overhead hoist Slowly raise and move cylinder to one side.
- ⑤ Attach chains or sling to the inner mast section at top crossmember. Using an overhead hoist slowly raise the mast straight up and out of middle mast section.
- ⑥ Attach chains or sling to the middle mast section at top crossmember. Using an overhead hoist slowly raise the mast straight up and out of outer mast section.
- ⑦ Replace mast and reverse above procedure to install Make all necessary measurements and adjustments.

6. CHAIN

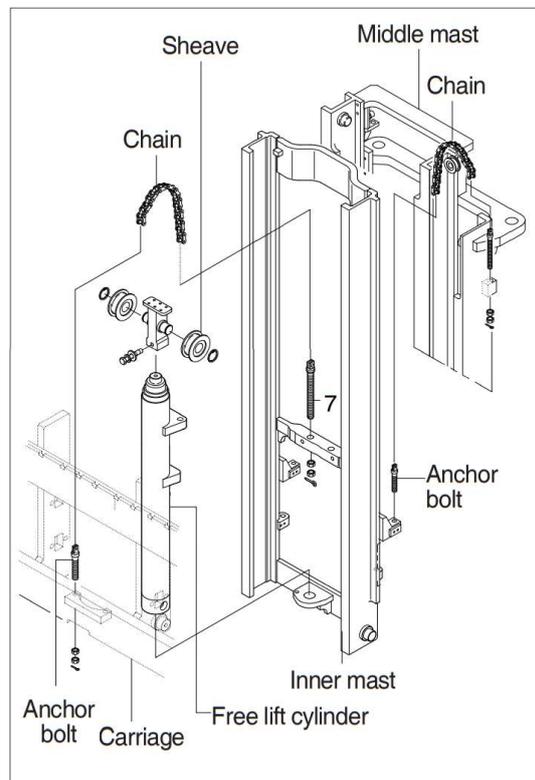
1) CHAIN SHEAVE

- ① Place a sling around carriage and attach to an overhead hoist. Lift carriage high enough so that the tension on the chain over sheaves is relieved. Position wooden blocks under the carriage and lower it.
- ② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins and drape the chains over the carriage.
- ③ Remove retaining ring securing sheaves to sheave support. Remove sheaves and bearings.
- ④ Remove bearing retaining ring from sheave and press bearings from sheaves.
- ⑤ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑥ Reverse the above to assemble and install. Use new split pins in chain anchor pins.



2) REAR CHAIN SHEAVE (TF MAST)

- ① Raise and securely block carriage and inner mast section.
- ② Remove the split pin securing the chain anchor pins and discard. While supporting the chains, remove the chain anchor pins from outer mast section.
- ③ Remove chains.
- ④ Remove retaining ring securing chain sheaves to sheave support. Remove sheaves and bearings.
- ⑤ Remove bearing retaining ring from sheave and press bearings from sheaves.
- ⑥ Thoroughly clean, inspect and replace all worn or damaged parts.
- ⑦ Reverse the above procedure to assemble and install. Use new split pins in chain anchor pins.



- 3) CHAIN WHEEL BEARING SUPPORT (TF MAST)
- ① Remove the carriage assembly and move to one side. Remove bolt securing chain wheel bearing support assembly to lift cylinder.
 - ② Attach a sling to the chain wheel bearing support assembly. Using an overhead hoist, lift support assembly straight up and off of lift cylinder. Move assembly to work area.
 - ③ Remove retaining ring securing chain wheel bearing to chain wheel bearing support.
 - ④ Remove bearing retaining ring from chain wheel bearing and press bearings from chain wheel bearings.
 - ⑤ Thoroughly clean, inspect and replace all worn or damaged parts.
 - ⑥ Reverse the above procedure to install.
- 4) Rear chain (TF mast)
- ① Remove the carriage assembly and move to one side. Refer to carriage removal and installation.
 - ② Raise and securely block truck approximately 6 inches from the floor.
 - ③ Using a sling or chain around inner mast section attached to an overhead hoist, slowly raise inner mast until there is enough slack in the chains to remove them. Secure inner mast section.
 - ④ Remove split pins and chain anchor pins securing chains to chain anchor(part of inner mast). While supporting the chains, remove split and chain anchor pins securing chains to chain anchors attached to outer mast section.
 - ⑤ Remove chains.
 - ⑥ Reverse the above to assemble and install. Use new split pins in chain anchor pins.
 - ⑦ Refer to this section for Load chain lubrication and adjustment.
- 5) Carriage chain
- ① Place a sling around carriage front plate and attach to an overhead hoist. Lift and secure carriage high enough so that split and chain anchor pins on carriage can be easily be removed. Remove chain anchor pins from carriage and drape chains out over carriage.
 - ② Place a wooden block under the carriage and lower the carriage on the block.
 - ③ While supporting the chains, remove split pins and chain anchor pins from chain anchors.
 - ④ Remove chains and wash them with solvent. Refer to this section for Load chain inspection and maintenance.
 - ⑤ Reverse the above to assemble and install. Use new split pins in chain anchor pins. Refer to this section for Load chain lubrication and adjustment.
- 6) Load chain inspection and maintenance
- After every 200 hours of truck operation, lift chains should be inspected and lubricated for the following chain conditions:
- ① Wear
- As the chain flexes on and off the chain wheel bearings, the joints very gradually wear. The stretch a chain develops in service is due to material being worn off at the pin outer diameter and pitch hole inner diameter on the inside plate.
- Chain wear can be measured using a wear scale or steel tape. When chains have elongated 2%, they should be discarded. When checking chain wear, be sure to measure a segment of chain that operates over a sheave. Do not repair chains by cutting out the worn section and splicing in a new piece. If part of the chain is worn, replace whole chain.

② Rust and corrosion

Chains used on lift trucks are highly stressed precision components. It is very important that the "as-manufactured" ultimate strength and fatigue strength be maintained throughout the chain service life. Corrosion will cause a major reduction in the load-carrying capacity of lift chain or roller chain because corrosion causes side plate cracking.

③ Cracked plate

The most common cause of plate cracking is fatigue-failure. Fatigue is a phenomenon that affects most metals and many plastics. After many repeated heavy loads, the plates may crack and the chains will eventually break. Fatigue cracks are almost always found through the pitch holes perpendicular to the pitch line. Contrast to this, random failures are caused by stress-corrosion cracking. If cracks are present, replace whole chain. Noise in the chain indicates that the plate is on the verge of cracking and will fail before long.

④ Tight joints

All joints in lift chain should flex freely. Tight joints resist flexure, increase internal friction, thus increasing chain tension required to lift a given load. Increased tension accelerates wear and fatigue problems.

Tight joints in lift chains can be caused by:

- Bent pins or plates.
- Rusty joints.
- Peened plate edges.

Oil rusty chains and replace chains with bent or peened components.

⑤ Protruding or turned pins

Heavily loaded chains in operation generate tremendous friction between pins and plates. In extreme cases, the frictional torque in the joint can actually turn pins to outside plates. If chain is allowed to operate in this condition, the pins slowly work out of the chain causing chain failure. Turned pins are instantly damaged as the flats on the V heads are no longer in line. Chains with turned or protruding pins should be replaced immediately. Do not attempt to repair the chain by driving pins back into the chain.

⑥ Chain side wear

A wear pattern on pin heads and outside plates indicates misalignment. This condition damages chain and sheaves as well as increasing internal friction in the chain system.

⑦ Chain anchors and chain wheel bearing

An inspection of the chain system includes a close examination of chain anchors and chain wheel bearings. Check chain anchors for wear, breakage and misalignment.

Anchors with worn or broken fingers should be replaced. Anchors should be adjusted to eliminate twisting or other misalignment in the chain. When chain is misaligned, load is not distributed uniformly between the plates. Prolonged operation will result in premature fatigue failure. Chain wheel bearings with badly worn flanges and outside diameter should be replaced. Heavy flange wear indicates chain misalignment.

⑧ Chain wear scale

The chain can be checked for wear or stretching with the use of a chain wear scale. Stretching of a chain is due to the elongation of the pitch holes and wearing of the pin O.D. The greatest amount of stretching occurs at the areas of the chain that flex over the sheaves most frequently. Check the chain at this point with a scale. The wear scale has instructions printed on the sides for use in determining chain stretch and are as follows:

- Determine pitch length of chain using 6 inch scale on one side of wear scale.
- If pitch is 1/2 (12.7 mm), 3/4(19.05 mm), 1(25.4 mm), 1-1/2(38.1 mm), 2(50.8 mm), use side A of scale
- If pitch is 5/8 (15.875 mm), 1-1/4(31.75 mm) or 2(50.8 mm), use side B.
- Align point A or B to center of a pin and note position of the opposite A or B point.
- If other point also lines up with a pin, the chain is worn and should be replaced.

If any of the above conditions exists (cracked plates, turned pins, stretching etc.), the chains should be replaced in pairs as a complete assembly. Order chains by part number to insure the correct chain length, pitch and material specifications.

7) Load chain lubrication and adjustment

① Lubrication

The most important consideration in field maintenance of lift chains is lubrication.

Hard working, heavily loaded chains cannot be expected to give satisfactory wear life without scheduled periodic re-lubrication.

Like all bearing surfaces, the precision manufactured, hardened steel, joint-wearing surfaces require a film of oil between mating parts to prevent rapid wear.

Oil must penetrate the chain joint to prevent wear. Applying oil to external surfaces will prevent rust, but oil must flow into the live bearing surfaces for maximum wear life.

Frequency of re-lube will vary with operating conditions and environments changing, the best estimate of lube period is 200 hours.

- Wipe off the old oil with a clean cloth and blow out the remaining dirt with compressed air.

▲ Wear eye protection

- With a clean brush, apply EP-140 extreme pressure lubricant or heavy motor oil (40W).

② Replacement

Replace chains as a pair. It will be virtually impossible to maintain uniform loading between the strands if a new chain is put into service opposite an old chain. The joints in the old chain will be greater than that on the new chain, greatly complicating the problem of maintaining equal chain tension. The new chain will wear more slowly causing it to bear the major portion of the load resulting in premature wear and fatigue failure. Don't steam clean or decrease new chains. The manufacturer's grease is effective in reducing wear and corrosion. If the original factory lube is dried out or wiped off, soak the new chain in heavy engine oil for at 1/2 hour prior to installing on truck. After the old chains have been stripped from the mast, carefully inspect chain anchors and chain wheel bearing. Broken, cracked or worn anchor must be replaced using the new anchor pin and split pin. Do not paint newly replaced chain after it has been installed.

③ Adjustment

Chain adjustments are important for the following reasons:

- Equal loading of chain.
- Proper sequencing of mast.
- Prevent over-stretching of chains.
- Prevent chains from jumping off sheaves if they are too loose.

④ Adjustment procedure

- With mast in its fully collapsed and vertical position, lower the fork to the floor.
- Adjust the chain length by loosening or tightening nut on the chain anchor. After making adjustment on the mast, be sure to tighten the nut.